Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

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APRIL 1959

IN HOT ENVIRONMENTS:

Hydraulics or Pneumatics?

Also in this issue

Let's Talk About the Soviet Lunik

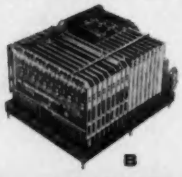
Thyratrons Control Large AC Servomotors

How Piping Influences Valve Performance



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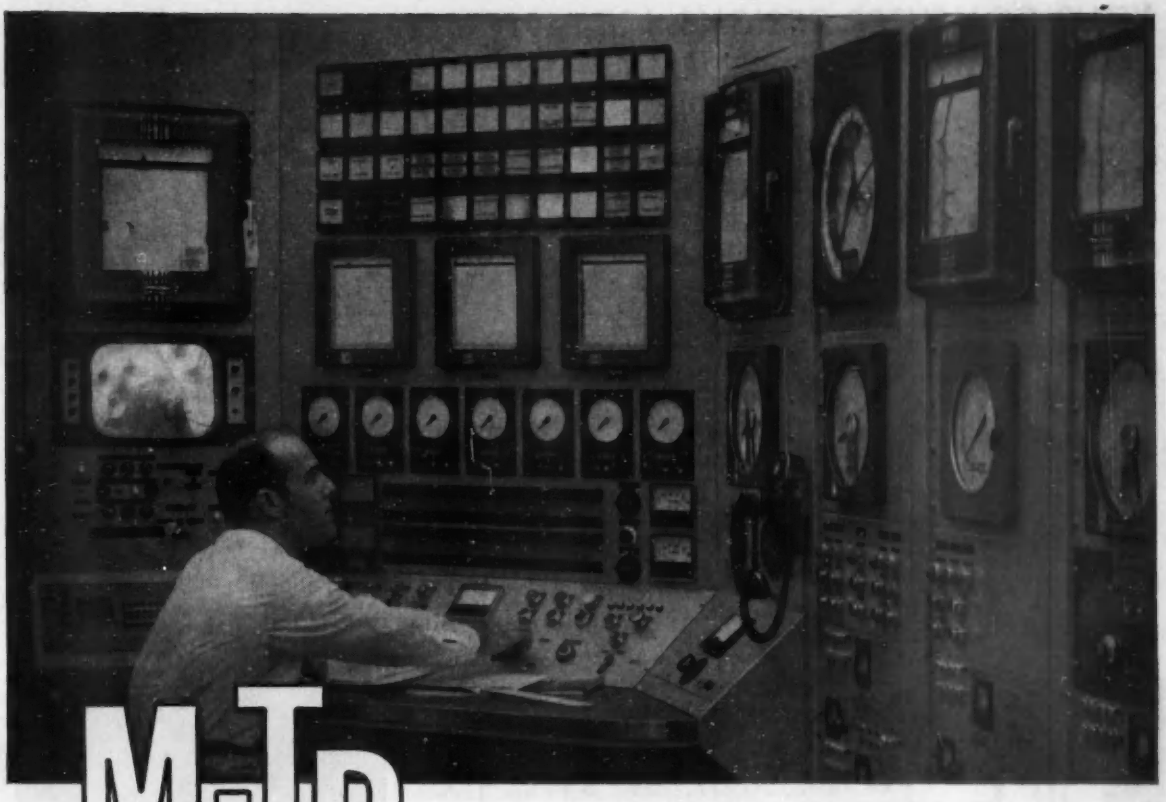
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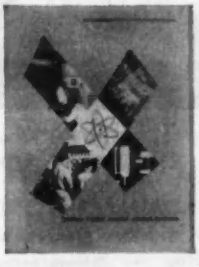
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At Massachusetts Institute of Technology, scientists depend on L&N instrumentation for control of their new research reactor. Designed by Dr. Theos J. Thompson of MIT and constructed by ACF Industries, this heavy water reactor facility is located in the heart of Cambridge. Specifications demanded not only accurate and dependable controls, but also, the necessary engineering experience so important to the safe and successful instrumentation of a reactor. Both were supplied by Leeds and Northrup.

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2N659	−20	10	70	55	2.5	65	12
2N660	−16	15	90	65	2.5	70	12
2N661	−12	20	120	75	2.5	75	12
2N662	−16	8	30 min	50	2.5	65	12

MEDIUM CURRENT, HIGH FREQUENCY, HIGH GAIN SWITCH



JETEC-30 Type	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. μsec
2N404	−24	12	30 min.	–	–
2N425	−20	4	30	18	1.0
2N426	−18	6	40	24	0.55
2N427	−15	11	55	30	0.44
2N428	−12	17	80	40	0.33

*I_C = 50 ma; I_{B_1} = 5 ma; R_L = 200 Ω; I_{B_2} = 5 ma; Grounded Emitter Circuit



SUBMIN Type	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. μsec
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CK26	−18	6	40	24	0.55
CK27	−15	11	55	30	0.44
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Control ENGINEERING

APRIL 1959
VOL. 6 NO. 4

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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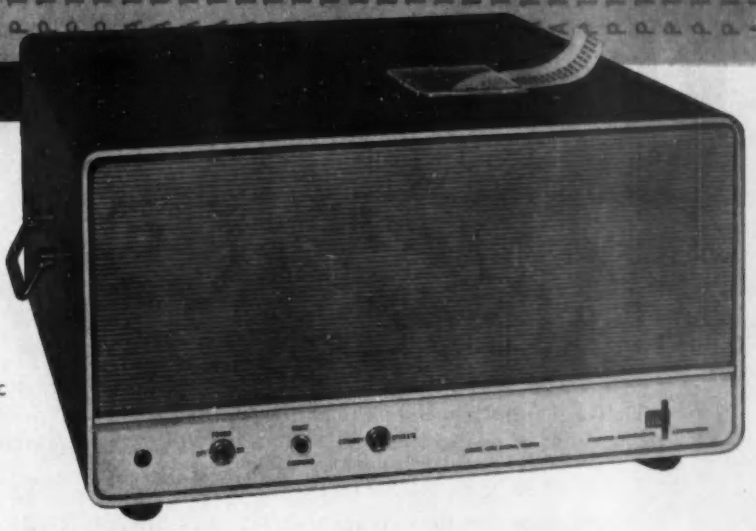
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	2 13/16	2—4	½	*
	3 5/16	5—8	¾	*
6⅛	2 13/16	2—4	½	2,500
	3 5/16	5—8	¾	*
8½	3 5/16	5—8	¾	5,000
10¾	5	10—16	1	8,000
13	5	10—16	1¼	12,000

*Limitation with these stems is dependent upon the maximum force available from each cylinder.



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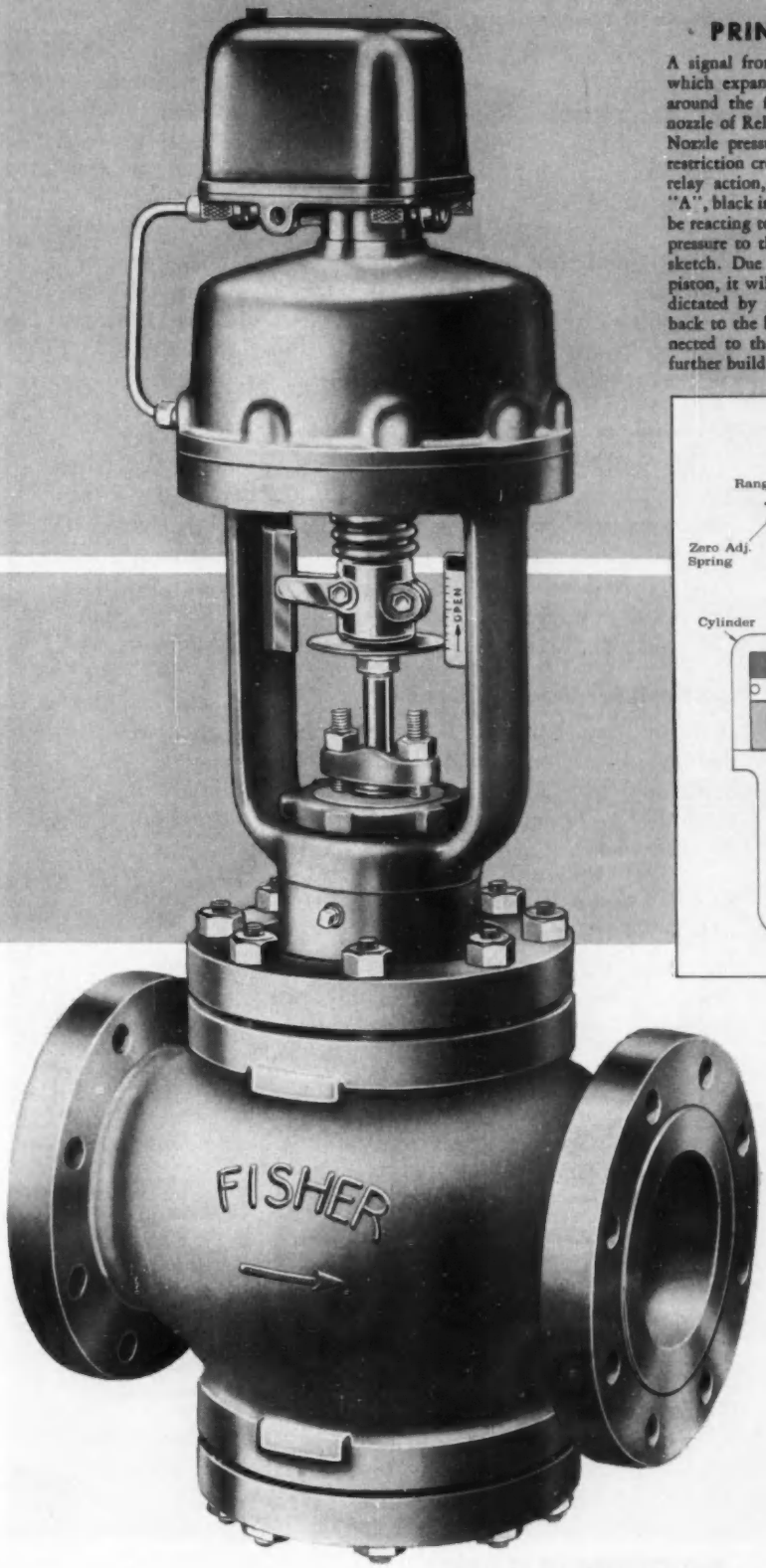
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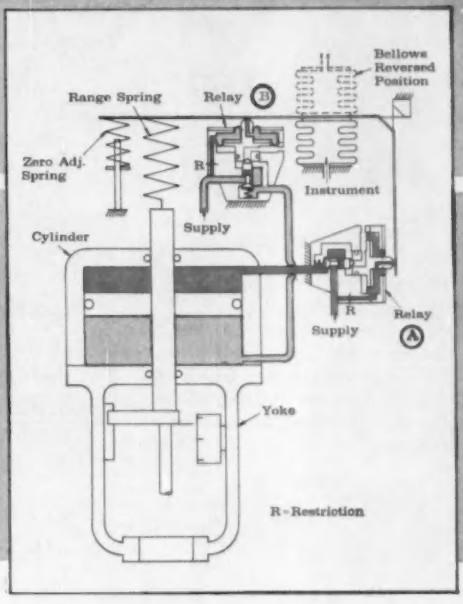
PNEUMATICALLY OPERATED PISTON . . .



Exterior view of high pressure actuator. Type 470 mounted on a Design "A" body.

PRINCIPLE OF OPERATION

A signal from the controller is received by the bellows which expand to move the beam. The beam will pivot around the fixed point and simultaneously uncover the nozzle of Relay "B" and cover the nozzle of Relay "A." Nozzle pressure will increase in Relay "A" due to the restriction created by the beam over the nozzle. Through relay action, the air pressure to the top of the piston, "A", black in the sketch, will be increased. Relay "B" will be reacting to the change in beam position to decrease the pressure to the under side of the piston, "B", red in the sketch. Due to the unbalanced pressures acting on the piston, it will move down, changing the valve position as dictated by the controller. The piston movement is fed back to the beam by means of a range spring that is connected to the piston rod extension, thus preventing any further build-up of pressure in the cylinder.

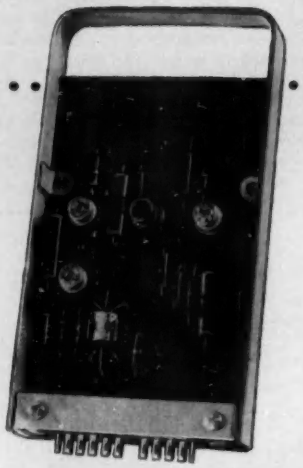


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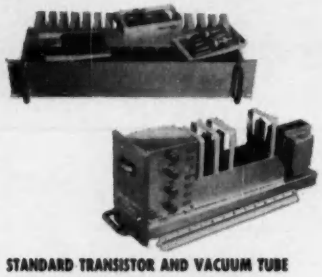
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SHOPTALK

Hot-stuff symposium

One-thousand deg F is hot under any circumstances, but particularly so when you're trying to operate hydraulic or pneumatic control systems in this environment. Still, progress is being made in developing control components that will operate satisfactorily there. To keep our readers up-to-date, CtE went to W. E. Mayhew of Republic Aviation and to C. H. Cannon of Lockheed, Georgia, got them to describe their studies in hot hydraulic and hot pneumatic systems, and then asked George Keller of Autonetics to discuss fluid control requirements in high-speed vehicles and to point out what to look for in choosing hydraulics or pneumatics. See page 89 for the results of this fluid-power symposium.

The word from Japan

Our faithful spare-time Japanese correspondent, Kazuto Togino, is due a vote of thanks from CtE readers. He has been responsible for "Servo Control Improves Precision Gear Hobber" (February 1959, page 90), "The Parametron—An Amplifying Logic Element" (page 110, this issue), plus miscellaneous news items. And this is only the beginning; watch CtE for information on more Japanese developments.

Last call for the conference

If you haven't already made your plans to attend the Purdue-CtE Conference on Industrial Control System Components on May 4 and 5, don't wait a moment longer. Page 35 gives the conference vital statistics, plus information on an added-starter technical paper and the banquet speaker.

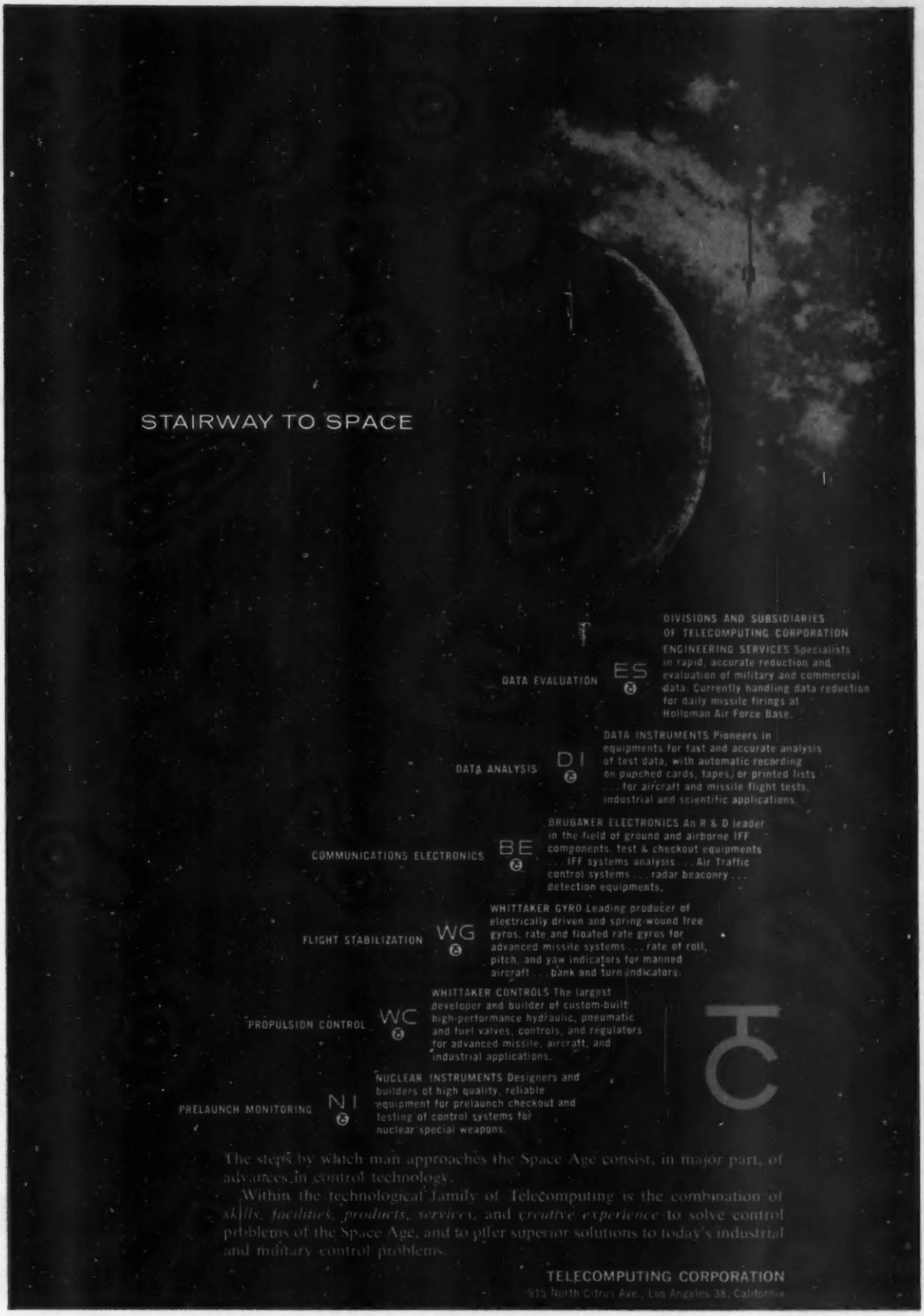
Karp on computing control

Last month Associate Editor Harry Karp again expounded on computing control, this time before the AIChE. Harry discussed the various roads to computing control, and gave details on commercially-available computing controllers.

Control engineer cross-fertilizes

Jake Valstar (author of "How Piping Influences Valve Performance", page 123) is a prime example of the common denominator in control engineering. Now a control systems engineer with Hughes Aircraft's Semiconductor Div., he was analyzing and designing new control systems for C. F. Braun & Co. when he authored the articles on selecting control valves. Jake was graduated as an EE from the Technical College at Dorbrecht, The Netherlands, and worked in the measurement and control section of the Royal Dutch Shell research labs at Delft before coming to the States. He's currently doing graduate work at UCLA.




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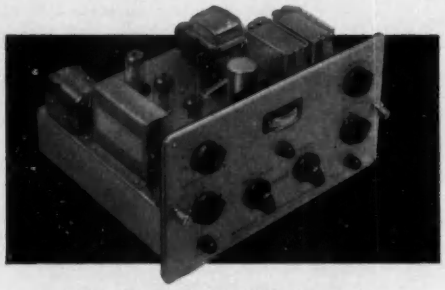
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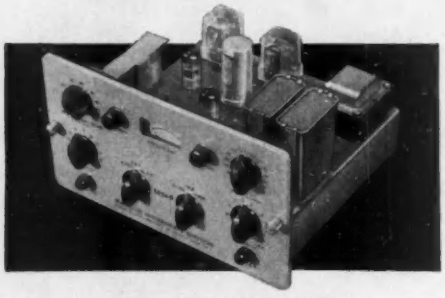
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the recorders advanced design



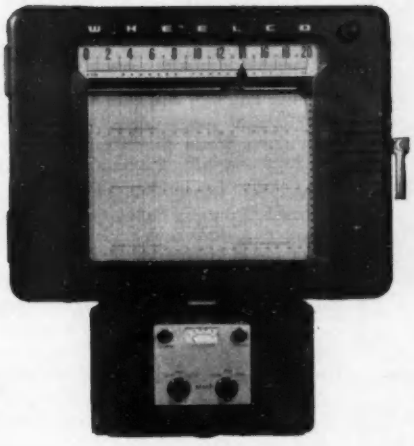
of principal elements on all Wheelco recorders permits fast adjustment, chart change, etc.

5. SIMPLE CHANGE OF BALANCING SPEEDS — changing a 15-second recorder to a 2-second recorder requires removing 3 steps of gearing. The two-phase balancing motor remains the same for all speeds.

ALSO FIELD-PROVED CONTROL FORMS WITH EXCLUSIVE MAGNETIC MODULATORS — Proportional rate and reset action on round and strip chart instruments offered by MM series controllers of the current output, position, or duration type.

SERIES 2000
ROUND CHART RECORDERS AND RECORDER CONTROLLERS

are also self-contained, null-balancing potentiometer instruments, the newest in the Wheelco line. Pen speeds are 1, 4, or 20 seconds at 60 cycles a-c. The 12-in. diameter chart has a calibrated width of 4⅝ in. Instrument accuracy is ± ¼ of 1% for all scale spans of pyrometric range. External control point setters are optional. All standard chart speeds are available; also a complete range of control forms including three-function type.



SERIES 8000
RECORDERS AND RECORDER CONTROLLERS

Self-contained, null-balancing electronic instruments designed for long life and trouble-free service. Wide range of models provides for measurement, indication, control, and permanent recording of temperatures and (with transducers) other variables such as speed, strain, ph, and any other quantities that can be resolved into electrical signals. Multipoint recorders handle up to 24 points at speeds from 3 to 24 inches per hour. Multibank (scanner) setups permit recording 144 or more points. Shown at left is recorder controller with automatic reset in tamperproof cover.

Rounding out the Wheelco line



Wheelco 9000 Series multiswitch indicators enable rapid checking of temperatures at as many as 108 stations. More stations require only an additional switch housing cabinet.



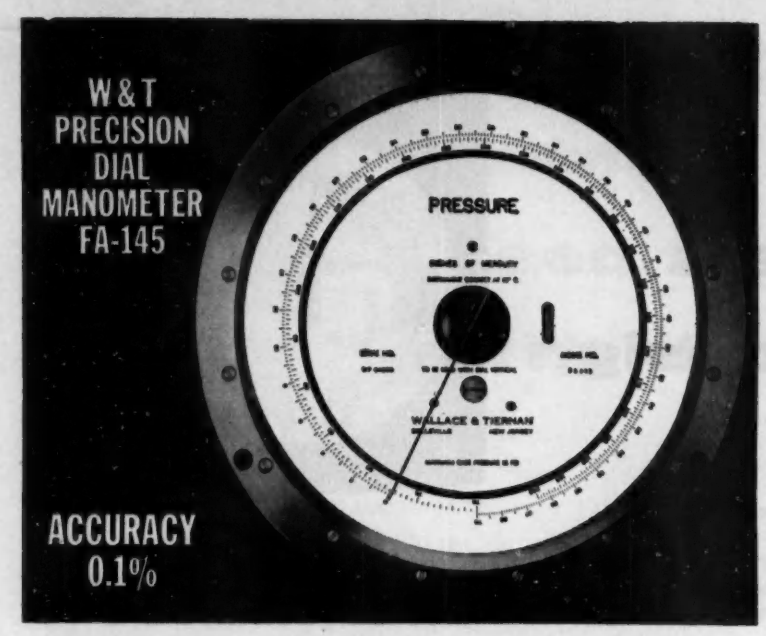
Circular scale 3000 Series indicators and Indicating Controllers have large, bold, distant-reading scales and generally parallel construction of 2000 Series recorders described above.

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CIRCLE 10 ON READER-SERVICE CARD

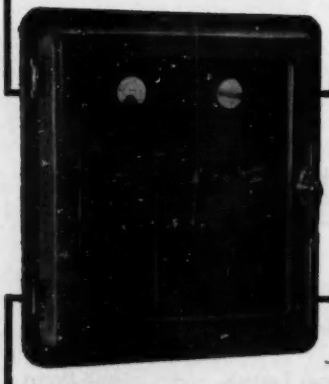


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Ranges:	0 to 120 inches of water (min.) 0 to 300 inches of mercury (max.) Other intermediate ranges available
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Write for Publication No. A-109.28

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CIRCLE 11 ON READER-SERVICE CARD



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New W&T Solvay Chlorine Detector*
detects as little as 3 p.p.m. chlorine in a continuous air-stream sample. Automatically sets off alarm at higher concentrations.

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1-55.28 *Manufactured under patent license from Solvay Process Div., Allied Chemical & Dye Corp.

CIRCLE 12 ON READER-SERVICE CARD

FEEDBACK

Information, please

To the Editor—

In your January '59 *Editorial* you write:

> "Topp Industries has a 72-step device for machine tool control which makes accurate five degree steps with a repetition rate in excess of 6,000 steps per sec, will stop and reverse in a fraction of a sec."

As we have not been able to find the address of the Topp Industries, would you kindly inform them that we are seriously interested in this component and should be very glad to obtain particulars about it.

Bertil Palme
Philips Teleindustria AB
Stockholm, Sweden

Write to Frank T. John, assistant to the president, Topp Mfg. Co., 5221 W. 102 St., Los Angeles 45. Ed.

To the Editor—

For the past several months I have become increasingly interested in the general field of automatic function testing. Information presented by you in the last two issues of Control Engineering has prompted me to write for some further data on the subject.

Our products, both in the development and manufacturing groups, are becoming more complex and require large groups of highly skilled engineers and technicians.

Whenever possible in production, we have been employing automatic continuity, hi-pot, and component testing. This static testing has reduced test time considerably and has helped to reduce the effects of the lack of highly skilled test and troubleshooting personnel.

It is obvious that a system of automatic dynamic testing of equipment is a partial solution to the problem of lack of skill. To this end I would appreciate any information you can supply regarding companies using or selling commercially this type of equipment, and any that may allow visits to see such equipment in operation

Harold Wexler
Manager, Engineering Services
Lewyt Mfg. Corp.
Long Island City, N. Y.

Among those that engineer and manufacture such systems are: American Bosch Arma, Chicago Div., 5857 W. 95th St., Oak Lawn, Ill.; Industrial Systems & Controls, Hughes Products Div., 5261 W. Imperial

COMPUTER PROGRESS FROM GENERAL ELECTRIC



AUTOMATED BANKING—WITH THE EXCLUSIVE G-E MAGNETIC INK CHARACTER READER—MADE PRACTICAL FOR BANKS OF ALL SIZES...NOW!

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The installation of the first G-E banking system is proceeding according to plan. Other systems are undergoing initial testing.

For more information, write or wire for brochure CPB-87... for information regarding any computer problem, programming assistance, mathematical analysis, and computer time rental, contact: Computer Department, Room 220 General Electric Company • Deer Valley Park • Phoenix, Arizona

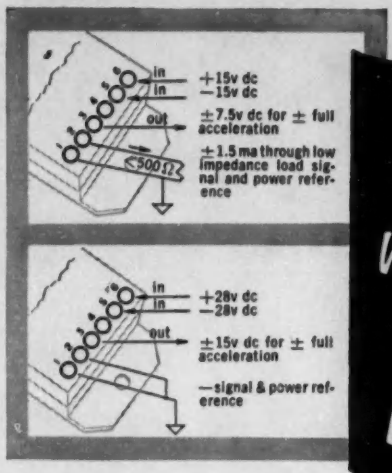
Progress Is Our Most Important Product

GENERAL ELECTRIC

FOR FIGURES IN A HURRY—FIGURE ON A GE COMPUTER

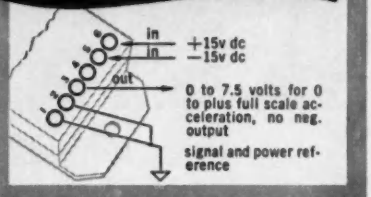
CIRCLE 13 ON READER-SERVICE CARD

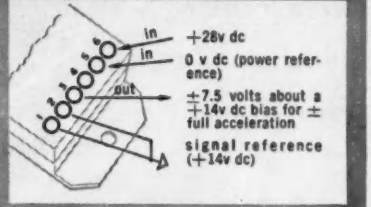
CPA-18 (4-60)

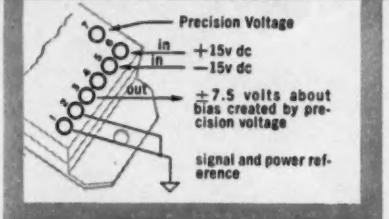


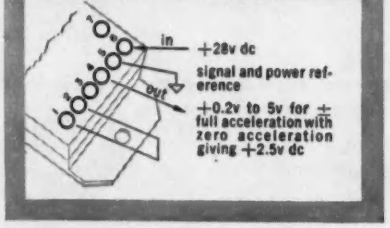
6 ways to solve CONTROL PROBLEMS with DONNER ACCELEROMETERS

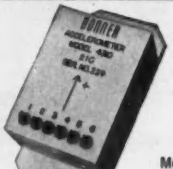
Donner 4300 series 0.1% transistorized force balance accelerometers can be connected in a number of ways to solve various control and measurement problems. Typical operational hookups for applications in telemetering, servo stabilization, gyro erection, acceleration switching, and short range inertial guidance are shown.



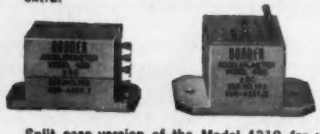








Model 4310 high output, high resolution accelerometer. Key specifications: non-linearity plus hysteresis, within 0.05% deviation from best fitted straight line; standard ranges, between ±0.05g full range and ±30g full range; resolution, better than 0.0002% full scale; weight, 3.5 ounces; standard output, ±7½v dc and/or ±1.5 ma full scale; options, biased output, fluid-filled units, and/or 28v dc operation; price, $450. f.o.b. Concord, California, options extra.



Split case version of the Model 4310 for use in limited space applications; electronics on right, sensing unit on left.

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14

CIRCLE 14 ON READER-SERVICE CARD

FEEDBACK

Highway, El Segundo, Calif.; Electronics Support Dept., Area 6, Radioplane Co., 8000 Woodley Ave., Van Nuys, Calif. Ed.

Takes wrong road but gets there

To the Editor—

There are some minor errors in the article, "How to Design Wide-Band Constant Phase-Shift Networks", R. White, Control Engineering, Nov. '58, pp. 108-109, which fortunately do not vitiate the results.

From Equation 9, given below for convenience,

$$\alpha_T/2 = \tan^{-1}(1/\omega R_2C_2) - \tan^{-1}(1\omega R_1C_1) + 90 \text{ deg} \ldots (9)$$

there follows

$$\tan(\alpha_T/2 - 90 \text{ deg}) = \frac{\omega R_1C_1 - \omega R_2C_2}{1 + \omega R_1R_2C_1C_2},$$

or

$$\tan(\alpha_T/2) = \frac{1 + \omega^2 R_1R_2C_1C_2}{\omega(R_2C_2 - R_1C_1)} \ldots (I)$$

which is not the same as Equation 10.

This can be checked by any one of the following methods:

(i) Let ω tend to zero and infinity in Equations 9 and I.

(ii) Observe the behavior of the vectors bd and be in Figure 3 as ω tends to zero and infinity.

(iii) Examine the circuit diagram in Figure 2 when the signal frequency is very low and very high.

By setting $X = \omega R_2C_2$, $K = R_1C_1/R_2C_2$, Equation I becomes

$\tan(\alpha_T/2) = (1 + KX^2)/X(1 - K)$, which has a minimum value of

$2\sqrt{K}/(1 - K)$, when $X = \sqrt{K}$.

If the smallest permissible value of α_T is given, the equation

$\tan(\alpha_T/2) = 2\sqrt{K}/(1 - K)$

can be solved for K by setting $K = \tan^2\theta$, which gives

$$\tan(\alpha_T/2) = \tan 2\theta.$$

Hence

$$\theta = \alpha_T/4$$

and

$$K = \tan^2(\alpha_T/4)$$

In the chosen example,

$\alpha_T/4 = 21.25$ deg.

Therefore,

$K = 0.1512.$

Returning to the author's derivation, Equation 11 does not follow from 10, for there has been a sign change.

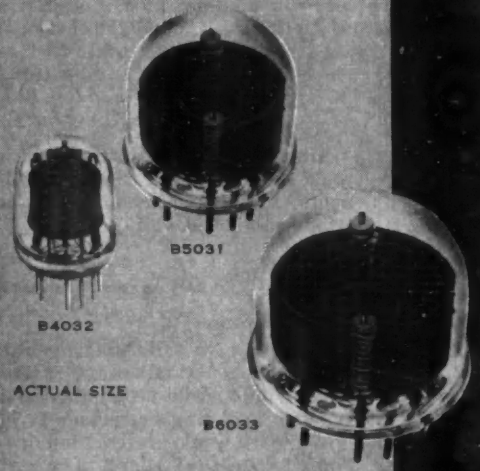
The combination of the errors in reciprocation and sign result in replacing the angle $\alpha_T/2$ by $(90 \text{ deg} - \alpha_T/2)$; Figure 4 must therefore be turned upside down. The curve drawn then starts at 90 deg and tends to 90 deg for large frequencies. Also the upper limit on $\alpha_T/2$ must be replaced by the lower limit, so that the author's

CIRCLE 15 ON READER-SERVICE CARD →

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NEW

ULTRA LONG LIFE NIXIE® TUBE



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the *most* dramatic development in indicator tube history

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There are three distinct ultra long life Nixie tube sizes available — miniature, standard and super. These complement the regular line of Nixie tubes where extraordinary life is required.

Continued pioneering in the development of indicating tubes coupled with extensive production facilities has enabled Burroughs to develop the most "perfect" in-line indicating tube ever mass produced.

The Nixie tubes are gas-filled, cold-cathode, ten-digit ("0" thru "9") numerical indicator tubes having a common anode. They are **all electronic,** in-line readout devices which provide an ideal means of converting electro-mechanical or electronic signals directly into readable characters.

NIXIE Tube Exclusive Features:

- **All Electronic**
- **Lowest Cost**
- **Lowest Power**
- **Lightest Weight**
- **Most Readable for Number Size**
- **Smallest Volume any Number Size**
- **Maximum Temperature, Shock and Vibration Specs**
- **And Now, Longest Life**

ANOTHER ELECTRONIC CONTRIBUTION BY

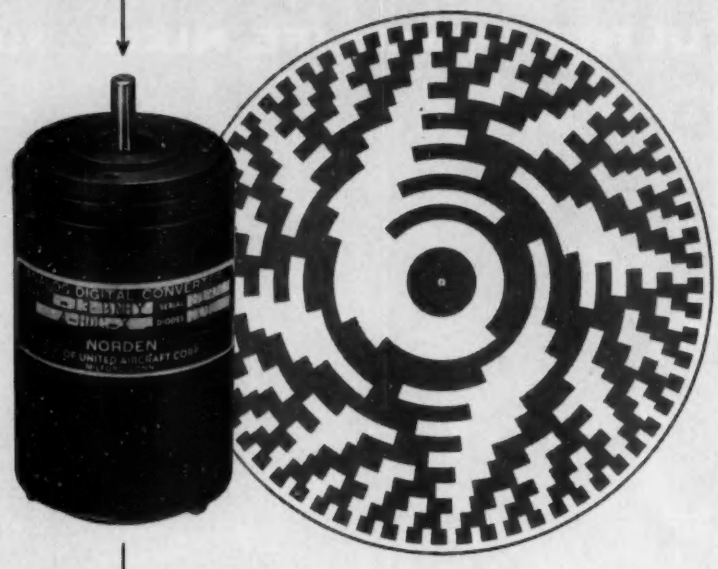
Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

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ANALOG DATA TRANSLATED



INTO CODED SIGNALS THROUGH

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CIRCLE 16 ON READER-SERVICE CARD

FEEDBACK

figure of 47.5 becomes 42.5, which is (90 − 47.5) deg.

Finally the measured phase angles would appear to be out by 180 deg and should be replaced by their complements with 180 deg.

From a practical point of view, no serious errors have resulted from the incorrect transition from Equation 9 to Equation 10: the object of designing a circuit has been achieved.

R. S. J. Good
Ferranti, Ltd.
Edinburgh, Great Britain

After all that, the equations which you'd use in practical design are still right. Only the derivation is in error at one point. Ed.

Perforations, continued

To the Editor—

Your move in perforating the feature section of Control Engineering certainly meets with my approval as a first step in the right direction.

While the whole matter of information retrieval is the subject of current extensive consideration and research, until a major breakthrough is made printed material stored by individuals remains of primary importance. Unless such storage is at least reasonably systematic, the material might equally well be thrown out immediately.

There are, I believe, two primary forms of storage in extensive use: filing cabinets and notebooks. In both forms, the semistandard 8½ x 11 size predominates and most notebooks are of the three-hole variety.

From the standpoint of the individual, therefore, it seems to me that all journals carrying technical material of permanent reference value should be published in an 8½ x 11 format, should be prepunched for a three-ring notebook, and bound (as you have) in such a manner as to facilitate removal of individual articles.

Since even when successive articles are considered of permanent interest by an individual, he may not wish to file them together, it is desirable that each article begin at the top of a right-hand page. Any blank pages or parts of pages resulting could carry advertising material.

Charles H. Dawson
Head,
Dept. of Electrical Engineering
University of Rhode Island
Kingston, R. I.

What am I offered for a dime-store punch? Ed.

CIRCLE 17 ON READER-SERVICE CARD →

A HOFFMAN SEMICONDUCTOR APPLICATION CASE HISTORY



THIS CONTROL PROBLEM HAD TO BE SOLVED

FOR AUTOMATIC DOLLAR BILL CHANGERS



Hoffman Silicon Solar Cells were the solution



A.B.T.'s (division of Atwood Vacuum Machine Co., Rockford, Illinois) intricate control problem in their unique "bill changer" required Hoffman Silicon Solar Cells, of exacting quality, to automatically register the authenticity of a dollar bill, in this innovation in automatic vending.

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Hoffman Silicon Solar Cells, born from the same family as those which are still powering the U. S. Navy's Vanguard satellite's radio transmitter, can be the answer to your control problem. For details consult the Hoffman Solar Cell applications specialist in your area or write to Department SS.

If you need a job in electronics done quicker and better, contact

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*(Per R.C.A. Laboratories, Princeton, New Jersey, Report No. 212-PH-55-91 [1114], April 15, 1957)

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Harold Chestnut

Mr. Feedback Control

To many control specialists today, Mr. Feedback Control is Harold Chestnut, the 41-year-old, scholarly control systems engineer at General Electric's General Engineering Laboratory. Responsible for this reputation are his considerable contributions to the field, primarily two books which he has coauthored and his work in feedback control professional activities.

Many control engineers were first introduced to Harold Chestnut in *Servomechanisms and Regulating Systems Design*, which he coauthored with R. W. Mayer. Volume I was published in 1951, Volume II in 1955. And engineers have been running into him regularly at AIEE Feedback Control Systems Committee meetings. Chestnut was a member of the committee in 1955, vice-chairman in 1956, and chairman in 1957 and 1958 (his present term expires in August). In addition, he has been chairman of the Feedback Control Systems Subcommittee on Component Specifications (1956 and 1957) and vice-chairman of the North American Control Council (1957). When the International Federation of Automatic Control (IFAC) was formed in 1957, Harold Chestnut was elected its first president; he is serving a two-year term.

It takes a special kind of dynamo to pile all these extra professional activities on top of a full-time job as a control systems engineer. Chestnut is no meeting-attending dilettante. His forte is solid technical achievement, not administration. After graduating from MIT (BSEE in 1939, MSEE in 1940) Schenectady-born Chestnut came back to Schenectady to work for General Electric. Because his major had been power-system stability (his thesis: the stability of synchronous machinery) he was assigned to solve power problems with a network analyzer. In 1942 he was appointed an instructor on GE's Advanced Engineering Program.

In his first few years at GE, Chestnut worked on the fringe areas of control. GE's accelerated war program pushed him into the field completely. In 1943 he joined the Aeronautics & Ordnance Systems Div., and over the next 13 years he worked on a variety of control projects. For example, he designed a two-dimensional amplidyne control for a machine tool, to produce cams for a mechanical fire control system. In 1947 he was the systems engineer on Project Thumper, probably the U.S.'s first anti-missile program. Thumper was "thumped" in an economy wave, Chestnut wryly remembers, because Air Force planners decided there would not be any missile to defend against for a long, long time. In 1955, he was project engineer for the fire control system on the F-104.

A transfer to the General Engineering Laboratory in 1956, as a control systems engineer, brought Chestnut to the area of international control. Because of his newly widened interest in control, he suggested to his superiors that he attend the Heidelberg control conference in 1956. At the meeting, he ran into Purdue University's Rufus Oldenburger, who was drumming up interest in the formation of an international control



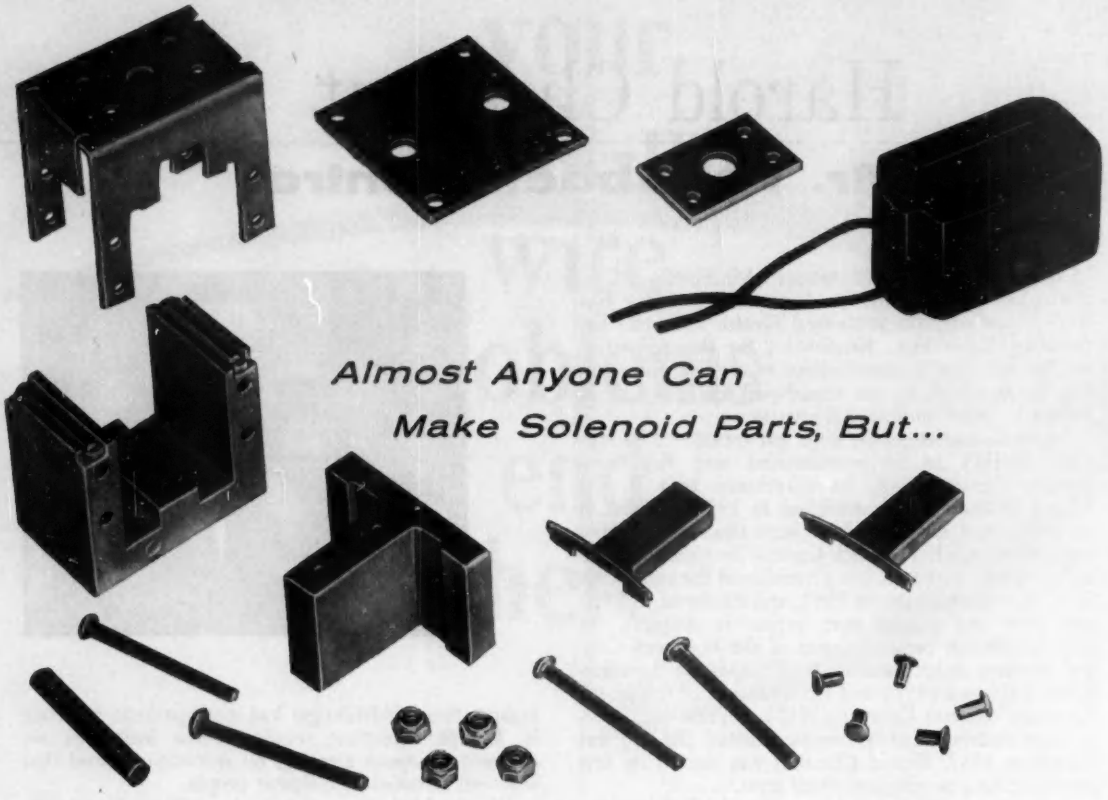
organization. Oldenburger had a sympathetic audience in Europe, Chestnut recalls. There had been six different European meetings on automatic control that year—all attended by different people.

Today, when Chestnut talks about IFAC, he gets the sparkle of a missionary in his eye. IFAC will play an important role, Chestnut feels, in providing a cosmopolite discussion ground for the engineers of many countries, particularly the small ones. The need was brought home to him sharply while visiting in Europe. At one gathering, he met a Polish control engineer who told him he had been unable to build a dc motor with the smooth characteristics described in Chestnut's book. What bothered the Polish engineer most, was the fact that there was nobody in his country with whom he could discuss this problem. Specialists in many countries, Chestnut says, are so few that they become isolated, have no one to talk through their problems.

He sincerely believes that in IFAC lies the makings of a better world. Says he, "Control is one area where it is pretty obvious how the engineer can help improve the standards of living of the world."

You might expect to find Mr. Feedback Control sticking close to his books for recreation. Surprisingly, he's an outdoor man. His favorite sport: skiing; close behind are camping, swimming, and tennis. These are family activities, shared with wife Erma Ruth and the Chestnuts' three sons, Peter, 13, Tom, 11, and Andy, 5.

Chestnut considers himself primarily an application engineer, though he admits laughingly that "hardware people probably think I'm ivory-towered". At GE today, he studies such problems as combined analog-digital systems for both military and industrial applications, computing-control for the process industries, and reliability of control components, a subject which he feels is a major one in the control field. To solve these problems, Chestnut applies the concept and philosophy of feedback control; it is the approach you'd expect from the man called Mr. Feedback Control.



Almost Anyone Can Make Solenoid Parts, But...

Headache-Free Solenoid Application Takes Machine Tool Precision

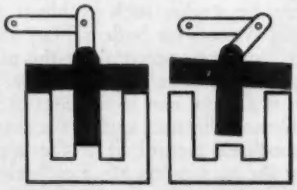


There may be solenoid application problems that we can't solve, but . . . we have yet to find one. It's simply because we are machine tool builders and fully understand the basic problems of converting electrical energy to mechanical energy. We've been at it for over 70 years. It's the reason why Namco solenoids have superior electrical and mechanical characteristics and why we can assure you of the one other factor that *truly* determines solenoid life...*proper application*.

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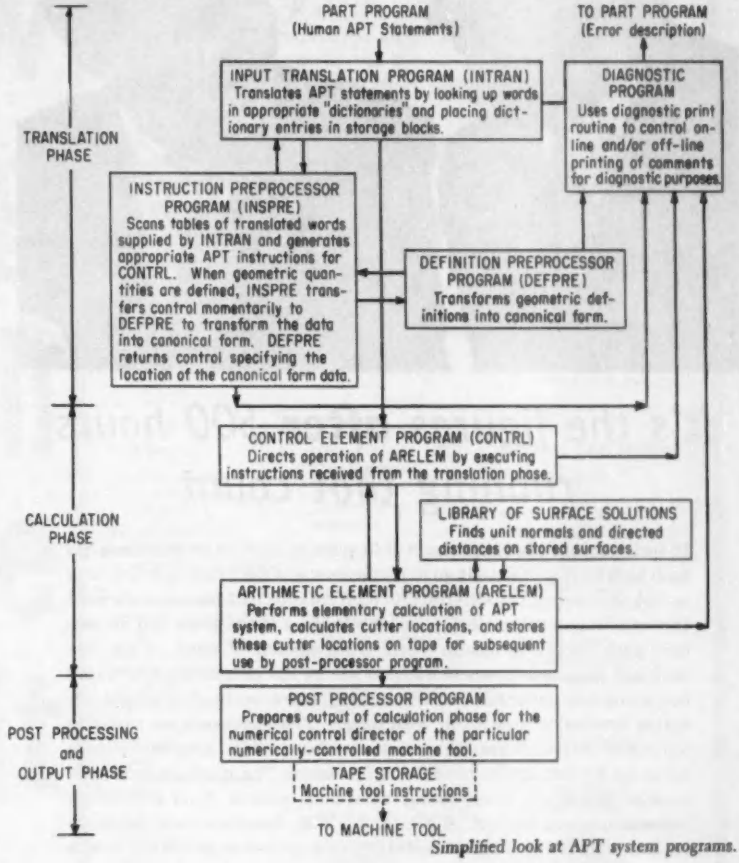
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Simplifies the Man-Machine Communication Problem

Continuous-path numerical control of machine tools is a powerful concept, but is difficult and uneconomical to use unless man is given mechanical assistance in converting drawing and design information into command instructions suitable for directly controlling the machine tool. The APT (Automatically Programmed Tool) computer—now ready for use—provides this assistance in a general-enough form to permit expansion to almost any type of machining function, even, possibly, to relieving the design engineer of much of the detailed design effort.

CAMBRIDGE, MASS.—For users of continuous contouring numerical control, a money-saving, time-cutting technique was unveiled last month. At MIT's Servo Laboratory, three cooperating organizations—MIT, the Aircraft Industries Association, and the Air Materiel Command of the Air Force—jointly announced the availability of the APT (Automatically Programmed Tool) system. The new aid: a computer program that transforms a general-purpose digital computer into a special-purpose "APT" computer capable of accepting English language and decimal dimension instructions (such as are needed to define shape, size, and machining details of a part expressed by an engineering drawing), and yielding the command instructions necessary for controlling any one of several commercially-available numerically-controlled tools.

Started over two years ago under Air Force AMC contract, APT was developed as a cooperative project between the MIT Servomechanisms Laboratory and 19 aircraft companies.



Simplified look at APT system programs.

Under the guidance of Douglas "Mr. APT" Ross, head, Computer Applications Group, Servo Lab, the coordinated effort led to the present status of the APT program (designated 2D-APT II). Future expansion has now been taken over by AIA's Numerical Control Panel, while the Servo Lab extends the basic system to a form called APT III, and beyond.

• **Why is APT needed?**—Most continuous-path numerical-control systems machine a series of straight lines. The length and number of lines depend on the degree of curvature of the machined path and the permissible machining tolerance. Manually preparing the instructions for one of these machines is complex, time consuming, and prone to human error. To do it, the programmer has to specify the coordinates of the end-points of each straight-line segment of the cutter-center locus and code this dimensional information, plus cutting instructions, for processing by a linearly-interpolating director. The director then provides the continuous input to the machine-tool servos.

In 1953, J. H. Runyon of the Servo Lab developed routines for Whirlwind I, permitting that com-



It's the figures **after** 500 hours' running that count

In designing the Muirhead range of Gearheads, particular attention has been paid to ensuring that good performance is maintained over a long period of running. To achieve this performance ball bearings are used throughout and the materials and dimensions of the gears and pinions have been chosen to ensure a minimum amount of wear. In fact the backlash does not exceed 45 mins. of arc at the output shaft after 500 hours' running under full load conditions, this measurement being made during reversal of an 8 oz./in. load torque. The Gearheads are versatile too; many ratios are available as standard, up to 600:1. Also two or more units can be cascaded to provide higher ratios. The standard mounting accepts the slight dimensional variations arising from differences between current Bu.Ord., R.A.E. and S.A.E. Specifications. Adaptors are available to enable the Gearhead to be mounted on size 08 and size 10 servomotors and to be used as a speed reducer, i.e. with its own input shaft. Although the main accent in design has been on long life and wear resistance, the Gearhead has successfully withstood the 28 day tropical exposure test of DTD 1085B mounted on a Mk 14 servomotor.

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puter to assume much of the computation burden for simple shapes. But these routines had one significant disadvantage: the input to the computer had to be in Whirlwind input code, and the machine cutting path had to be expressed in canonical form (the actual coefficients of the curve-defining equations). This meant that if the person preparing the machining instructions was unfamiliar with computer coding and programming, a human programmer had to be interposed between him and the computer. Such an arrangement limited the usability of computer assistance.

Some progress was made when Arnold Siegel developed for the Servo Lab an automatic programming routine that permitted the human programmer to express machining instructions in terms of circles, lines, points, intersections, etc., and in decimal dimensions, rather than in computer code (see "Automatic Programming of Numerically-Controlled Machine Tools", CtE, Oct. '56, p. 65).

Siegel's routine transformed the general-purpose computer into a special computer that could understand the language of the engineering drawing and deliver machining instructions in director-input language. It permitted computer instruction by persons who didn't know or care anything about computer input coding.

• **Interim programs fill the gap**— Siegel's work filled an important need for potential users of numerical control. Aircraft builders were getting ready to accept delivery on the costly numerically-controlled tools. They needed quickly some way of automatically instructing these tools, since the manual/desk-calculator method was clearly out of the question except for the simplest shapes. Many of the aircraft companies developed interim programs, most of them based on Siegel's approach, to tide them over until APT became a usable re-

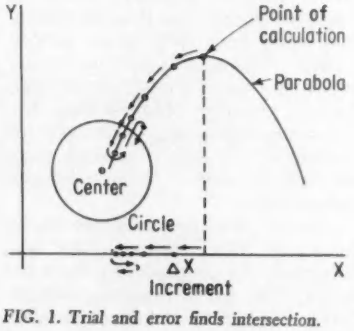
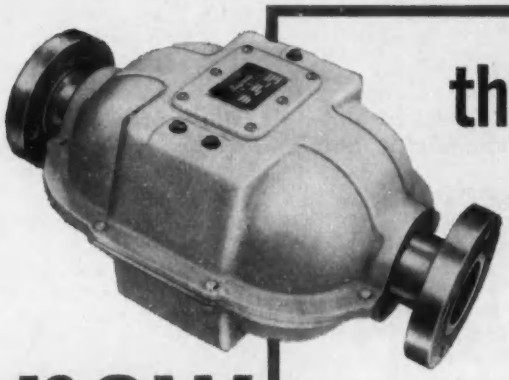


FIG. 1. Trial and error finds intersection.



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phosphoric acid
ethenol extract
scrubber recycle water
urea solution
nitrate solution
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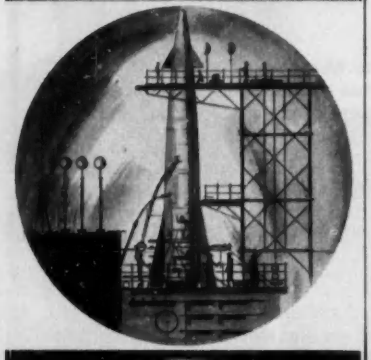
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. . . The result: a flexible routine whose capabilities can be expanded without an accompanying increase in complexity . . .

ality. (A typical interim program, used by Lockheed, Georgia, was reported in "Applying the IBM 704 to Milling-Machine Programming", CtE, June '58, p. 101.)

But all of these interim programs had a similar fault: each curve or shape had a separate complicated subroutine. Thus, as more and more complex shapes were handled, the number of subroutines grew larger and more unwieldly. And the input language became more complex. All of the interim programs were basically two-dimensional in nature; three-dimensional programming was done by means of the strata technique. In this, two-dimensional shapes of sections through a three-dimensional body were specified by the programmer. The technique either complicated the programming procedure or limited the shape-handling capabilities of the machine tool.

• **The systematic approach**—Applying his experience with the subroutine type of automatic program, Ross proposed a systematized approach. He suggested that the common and most difficult portions of the various subroutines be separated out and assigned to the arithmetic portion of the APT computer. The result: a flexible routine whose capabilities could be vastly expanded without an accompanying increase in complexity and difficulty of use.

Figure 1 shows a simple example of a systematized solution: locating the intersection of a parabola and a circle. A trial-and-error method is used, made possible because of the high speed of modern computers.

Starting at the top of the parabola, the computer moves along it toward the circle in equal steps, at each step computing the distance from that point to the center of the circle and comparing the distance with the known radius of the circle. After the required number of steps, the computer will know that it is within a specified tolerance distance of the intersection. Note that it is possible to pass the intersection without getting close enough to be within tolerance. If this happens, the computer retraces its steps, this time using an interval half the size of the original steps. Thus, the computer must finally find the intersection within tolerance.

Figure 2 shows a simple flow diagram of the completed program. While this flow diagram is not systematized as yet, note that the box labeled parabola can be replaced with a box containing the equation for any curve without disturbing the validity of the rest of the program. This leads to a systematized solution for finding the intersection of any curve and a circle: regardless of the curve, the hard part is the same and only simple subroutines are necessary to handle any curve. The same technique can be extended to three-dimensional work, and almost the same flow diagram can be used to find the intersection of any two-plane curves.

• **The present APT system**—Using

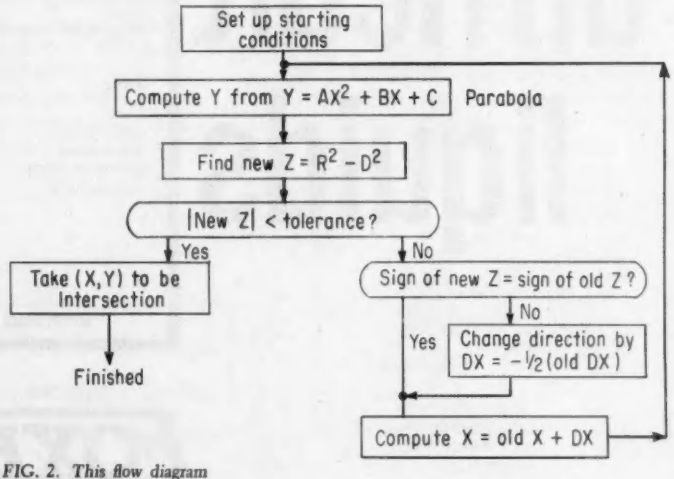


FIG. 2. This flow diagram can be easily generalized.

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Unit includes DC-voltage supply, AC-frequency source, square-wave modulator, and monitoring circuits for frequency and voltage adjustment.

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WHAT'S NEW

this approach, the APT computer was developed (see page 21 for a simplified functional diagram). Essentially, the computer translates the human APT statements into computer language, transforms geometric quantities into canonical form, performs the necessary calculations to determine tool path, and converts this tool path into instructions that are acceptable to a given numerical director.

The present 2D-APT II system has a 107-word vocabulary. While the basic program is three-dimensional (determining cutting paths by the intersection of arbitrary surfaces), the language is primarily two-dimensional. By proper manipulation, three-dimensional work can be done with the present system. The next step will be to develop APT III, a routine that will machine by surfaces rather than along curves, to simplify the handling of complicated 3-D shapes.

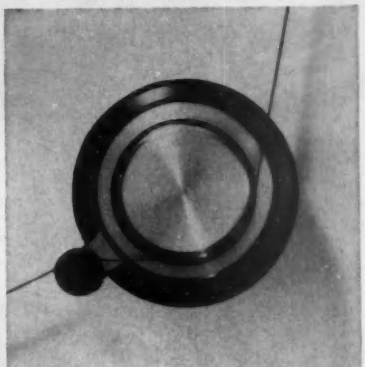
At the beginning of the project, a survey of the aircraft companies showed that the IBM 704 was the most available computer. The first APT program is designed to work on this machine. Future plans include developing programs for other large-scale computers, and for small-scale computers such as the IBM 650. Modified forms of APT, at least, will work on the smaller computers: it will just take longer for the computations.

As of now, post-processor programs have been written to handle the following numerical control systems: Concord Controls/G & L, Electronic Control Systems, Cincinnati Milling, Bendix, North American Numill, and the original MIT director.

• **Special features of APT**—A useful trick that can be performed by APT is to change the scale and proportions of the piece being machined. For example, if in the original program certain important dimensions of the part are defined in terms of words such as width, length, rad, etc., then by simply changing the dimensions that apply to these words, scale or proportion can be modified without revising the program. This could be useful in making scale models for windtunnel work.

The program is also designed to feed an oscilloscope. The programmer can view the part he has specified before the final machine-tool director control tape is prepared. On the 'scope, the object appears in proper perspective, and the point of view can be shifted to permit inspection from all angles. This is extremely useful for spotting gross errors in the program.

—B. K. Ledgerwood



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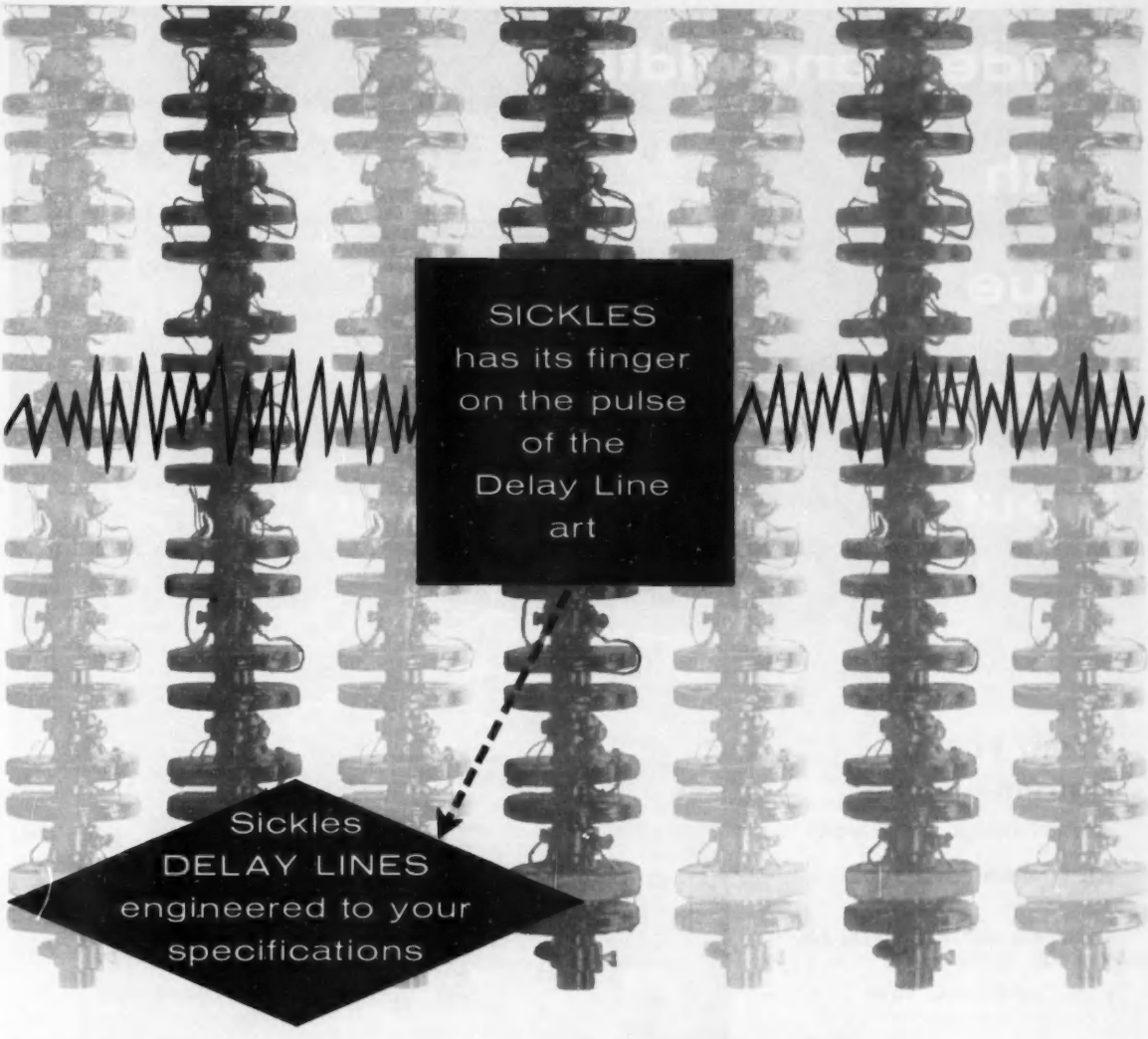
REEL DIAMETER	BASE THICKNESS (mils) 1.0	1.5
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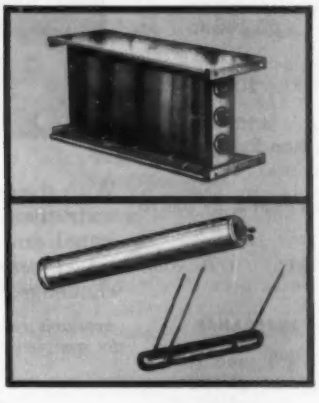
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Military Aircraft Business . . .

. . . still booms. The missile is not pushing manned airplanes out of the defense picture as rapidly as expected. And the percent of money slated for control systems continues to rise.

WASHINGTON—

Despite stories to the contrary, the advent of guided missiles isn't pushing the manned airplane out of the defense production picture as rapidly as some experts predicted.

And the chunk of the aircraft procurement dollar slated for control systems—for flight, navigation, and fire control—is rising steadily. Defense production officials estimate that from 30 to 50 percent of total aircraft costs now go for control systems.

• **Spending plans**—To be sure, the aircraft trend is down while the trend in missile spending is sharply on the rise (CtE, Jan '59, p. 59). But the Pentagon's budget for fiscal 1960, starting next July 1, reveals multi-billion dollar plans for aircraft development and production which are likely to run far into the 1960's. Here, for example, is a rundown on the military budget for aircraft and missiles in fiscal 1960:

▶ Expenditures—reflecting the volume of shipments—for aircraft procurement will total $6.3 billion in fiscal 1960. The sum this year is $7 billion. Missile procurement spending will mount to $3.8 billion next year, compared to $3.3 billion in fiscal 1959.



▶ New appropriation requests for aircraft amount to $6.2 billion—up from the previous appropriation of $6 billion. The requests for new missile procurement funds total $3.5 billion—down from $4.1 billion appropriated for the current year.

▶ New contract awards for aircraft will total $6.8 billion next year, compared to the current volume of $7.3 billion. But new orders for missiles will also drop—from $4.1 billion this year to $3.8 billion next year.

The figures on new appropriation requests and contract awards are a tip-off that the transition from aircraft to missiles is going much slower than the imaginative forecasts made in recent years.

The new budget provides for procurement of several dozen more Boeing B-52 heavy bombers (beyond the 642 now scheduled), more Boeing KC-135 jet-tanker planes, and several dozen more Convair B-58 medium supersonic bombers (66 now scheduled). But the Air Force's aircraft shopping list for next year includes no more fighter-interceptor planes and fewer fighter-bombers.

The Navy will buy more all-weather fighter-interceptor aircraft (notably McDonnell's new F 4H-1) and fewer attack bombers. The Army will order more turboprop observation planes and fewer helicopters than this year.

• **R&D sets the pace**—The best



tip-off on future aircraft production lies in R & D plans. And here, too, the figures show the staying-power of manned planes in the over-all defense situation. New aircraft R&D contracts will amount to $487.3 million next year—up from $472.6 million this year. Missile R&D contracting will rise from $1.3 billion worth this year to $1.4 billion.

Here's a rundown on the major aircraft projects now in the R&D stage—weapon systems which may be pushed into production in the years ahead:

▶ **The Air Force's B-70,** six-engine supersonic heavy bomber. North American Aviation is prime contractor. The plane will be powered by exotic, boron-based fuel, is planned as the manned long-range bomber followup to the current B-52. The plane is not expected to be operational until 1964—which explains the decision to continue B-52 production. The plane will have a speed of Mach 3, a range of over 7,000 miles at 70,000 ft.

▶ **The Air Force's long-range F-108 fighter-interceptor.** North American Aviation is the weapon-system contractor. International Telephone & Telegraph Corp. holds the contract for major control systems. The operational target date is believed to be 1963. The plane will have a cruise speed of Mach 3, a cruise altitude of about 70,000 ft, and a gross weight of 100,000 lb.

▶ **The Air Force-Atomic Energy Commission** program to develop an aircraft nuclear propulsion system. This project has been stretched out; no target date has even been established for the first flight. The project is not considered a conventional weapon system; significant work is being conducted only on the power plant by General Electric and Pratt & Whitney. Convair and Lockheed are doing very limited design studies on the airframe.

▶ **The Air Force's Dyna-Soar** boost-glider or orbital bomber. Two teams of contractors are competing on design studies. One team, headed by Martin, consists of Bendix Aviation (communications), Goodyear Aircraft (crew escape capsule), Minneapolis-Honeywell (guidance and navigation systems), and American Machine & Foundry Co. (gantry and launching pad). The other team, headed by Boeing as weapon system contractor, consists of GE, Thompson Ramo Wooldridge, North American Aviation, Chance Vought, and Aerojet-General. Dyna-Soar will be a piloted space craft, launched to an altitude of about 100 miles by a multi-stage rocket booster producing some 335,000 lb of thrust (either the Atlas or Titan ICBM), then boosted along on its own trajectory by a 75,000-lb thrust engine of its own.

In essence, these manned planes of the future will perform as airborne



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CIRCLE 28 ON READER-SERVICE CARD

WHAT'S NEW

missile platforms. The F-108 fighter plane, for example, will be armed with Hughes GAR-9 nuclear-tipped Falcon air-to-air missiles. The B-70 will carry advanced, long-range air-to-surface missiles—most likely air-launched IRBMs.

The Air Force has already asked for bids on such a weapon—the project is called Bold Orion. Martin, Lockheed, and Convair are among the companies known to have done preliminary studies on the aerial IRBM.

There are still other aircraft projects in R&D. North American Aviation is developing a Mach 2 attack plane for the Navy, the A3J.

Bell and Convair are jointly developing a Mach 2 VTOL fighter plane (vertical take-off and landing), the F-109, for the Air Force.

A score of other companies are working on designs for VTOL aircraft for all three services.

• **New control systems**—The major innovation being talked about in the aircraft control field is the self-adaptive flight-control system. Such controls maintain desired performance throughout flight in a "closed-loop" fashion with a minimum of prior information about the vehicle's dynamic and other characteristics (CtE, March, p. 21). Right now concise knowledge is put into the system through what Air Research & Development Command officers call "three-dimensional cam gain changes". As many as 28 gain changes are now programmed for some operational flight-control systems.

An adaptive system is expected to be engineered into the B-70, F-108, and future manned planes with speeds of Mach 3 and over.

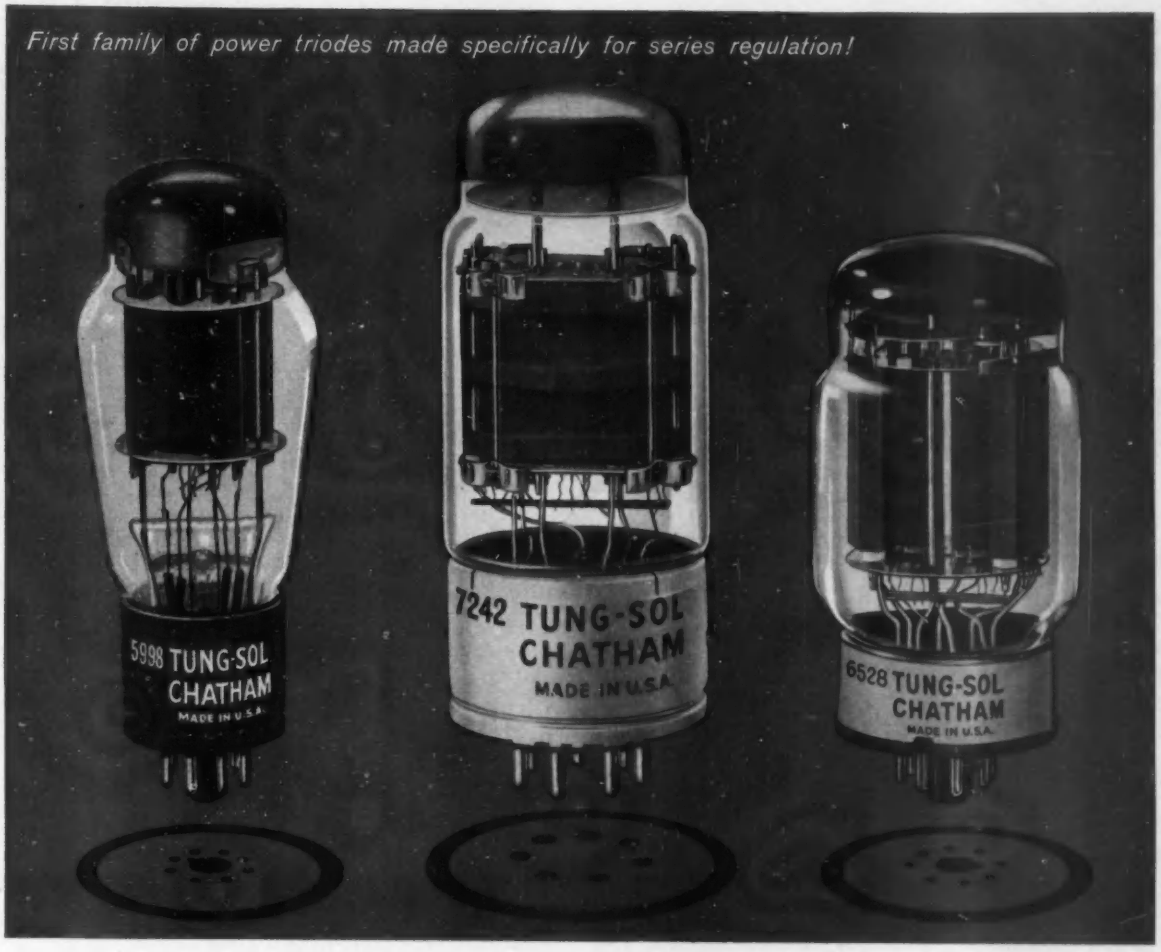
ARDC is also looking at all-mechanical flight-control systems to replace the all-hydraulic, electrohydraulic, or hydraulic-mechanical systems now being used. An all-mechanical system seems to have advantages in the extreme environmental conditions Mach 3 planes will encounter.

One project being surveyed is a Curtiss-Wright all-mechanical system developed for propellers which ARDC believes has applications for flight control systems. It involves a mechanical servo, with power transmission through a high-horsepower, low-torque operation, and then a radical step-down to a high-torque, low-rpm operation.

Against this backdrop of aircraft R&D efforts, it's obvious that the missile hasn't consigned the manned plane to the scrap heap.

—Morton Reichek
McGraw-Hill News

First family of power triodes made specifically for series regulation!



Tung-Sol/Chatham power triode family covers every series regulator need!

Now designers can specify a premium quality Tung-Sol/Chatham tube for all series regulator sockets. Tung-Sol/Chatham's family of power triodes — the first designed and produced specially for series regulator service — meets all design requirements and assures maximum reliability and life at all times.

Types include the new 100 Watters, 7241 and 7242, medium mu or low mu-high current. 12 or 26 Volt heater versions available on most types. All embody sturdy construction features that contribute to overall ruggedness and long hours of heavy-duty operation.

Compare the ratings below against your particular application! If you desire complete data sheets . . . or you have a specific design problem, contact us today! We'll be glad to give whatever assistance we can. Just write: Tung-Sol Electric Inc., Newark 4, N. J., Commercial Engineering Offices: Bloomfield and Livingston, N. J., Culver City, Calif., Melrose Park, Ill.

TYPICAL VALUES				
	Total Plate Current	Range of Tube Voltage Drop	Minimum Tube Drop	Grid Voltage Swing
[redacted]	200 ma	80 v	45 v	20 v
[redacted]	400	65	70	10
[redacted]	600	80	70	13

PERTINENT CHARACTERISTICS PER TUBE				
	Max. Plate Current	Max. Plate Voltage	MU	Gm
[redacted]	280	275	5.5	28,000 umhos
[redacted]	600	400	9.0	74,000 umhos
[redacted]	900	400	9.0	111,000 umhos

TUNG-SOL®

TUBE TYPES BY PLATE DISSIPATION RATINGS			
Total Plate Dissipation	26 to 30 W	60 W	100 W
[redacted]	6AS7G, 6082 6080WA, 7105	6336A 6394A	7241
[redacted]	5998	6528	7242



Sophisticated servo engineers with damping dithers are eliminating the cost and complication of lead-lag networks and notching filters by ingenious use of electromagnetic damping.

Beckman inertia damp and adjustable velocity damp servomotors give high frequency response ... help cut system clutter, size and weight ... reduce maintenance.

Servo systems simplified!

Wise designers are using 26-volt and 115-volt 400-cycle Beckman units, in sizes 8, 11, 15 and 18, in environments more hellish than imagined by MIL-E-5272A, where utmost reliability is paramount.*

Methodical engineers with sophisticated inclinations can get the inside story by writing for Data File G 43 ... a brief of inertia and velocity damp theory and practice.

*Names of companies now using these Beckman units are available on request.

Beckman® / Helipot®

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California
Engineering representatives
in 29 cities

1472

potentiometers : dials : delay lines : expanded scale meters : rotating components : breadboard parts

CIRCLE 30 ON READER-SERVICE CARD

WHAT'S NEW

Noninteracting Controller

...theorized for super-speed steam generation is now being tested by U. S. Navy. It overcomes long-time boiler transients to allow a speed-up in catapulting carrier aircraft.

PHILADELPHIA

At the U.S. Navy's Boiler & Turbine Laboratory, Navy engineers are testing hardware for a new concept in boiler control. Developed and built by Beckman Systems Div., the new controller will adjust two input variables in a prescribed manner so that neither drum pressure nor water level is disturbed.

The new concept of boiler control was prompted by the stringent requirements of today's naval aviation tactics. To catapult one plane on a modern aircraft carrier such as the USS *Saratoga*, for example, the steam rate jumps from 20 percent to 120 percent and then back to 20 percent—in a matter of seconds. On board the *Saratoga*, long-time boiler transients in the eight 260,000-lb-per-hour boilers still stand in the way of meeting the Navy's operational goal: to catapult one plane every 30 sec.

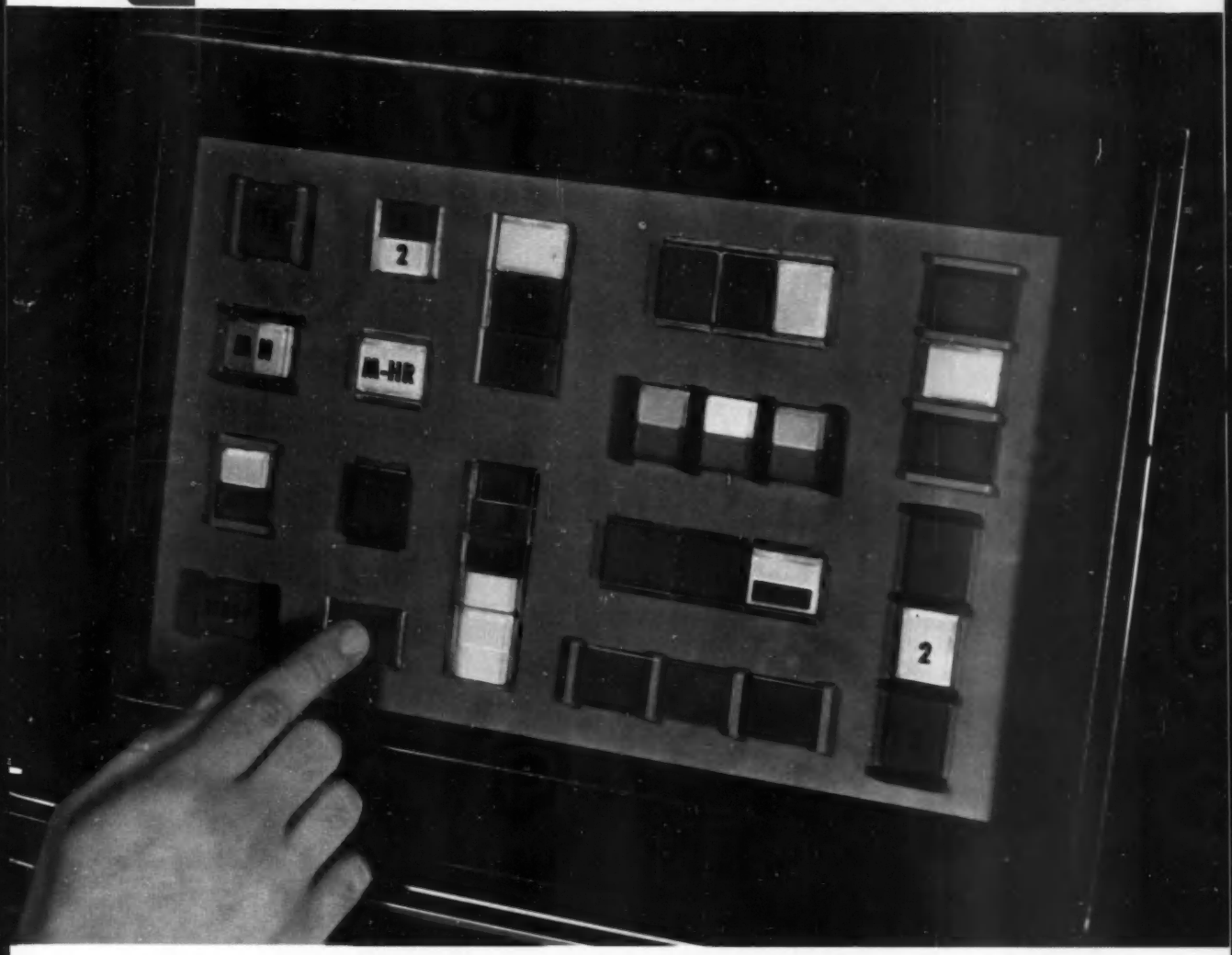
To shorten the minimum time between catapultings, the Navy decided that a new approach would be necessary. The result, after analysis and open-loop boiler tests (CtE, Oct. 1958, p. 95): a noninteracting variables control.

In a conventional approach, the controller senses drum-pressure change and sends a signal to the blower-speed and damper-area control valves to adjust fuel rate, thus bringing pressure back to its normal level. The change in fuel rate, however, causes a change in water level, which has to be corrected by adjusting the feedwater rate. Adjustment again affects drum pressure, so that fuel rate has to be further corrected. All this takes time. And until the boiler has stabilized after one catapulting, another plane cannot be launched.

The noninteracting controller will, adjust both fuel and feedwater rates so when the steam rate changes, neither drum pressure nor water level is disturbed. Purpose of the present tests is to see how much improvement the controller actually contributes. The Navy has connected the unit to a spare *Saratoga*-type boiler, has seen some evidence of improved boiler control.

—Harry R. Karp

CIRCLE 31 ON READER-SERVICE CARD →



All new Series 2 lighted display and pushbutton switch devices offer new modular versatility in lighted display

The modular concept of Series 2 devices opens a new approach to design freedom in both front-of-panel lighted display and back-of-panel precision pushbutton switching. The demonstration panel shown above illustrates some of the variety in arrangement and color and labeling offered by these new devices.

Principal advantages of Series 2 units include these:

Operator-indicator and indicator units are assembled quickly and easily, *without tools*. Even the switching units simply snap into place as shown on the next page.

Units are available, flange mounted or barrier mounted, in long-flange, short-flange, long-barrier and short-barrier types. All types can be combined in either rows or columns to provide eight group-mounting schemes.

Five colors of display screens are available—red, yellow, blue, green, and white. Two, three, or four lamps can be used in each unit. Color filter caps for the lamps are available to provide projected color on white frosted screens.

Two-color display screens may be split laterally or longitudinally, in any combination of the five colors.

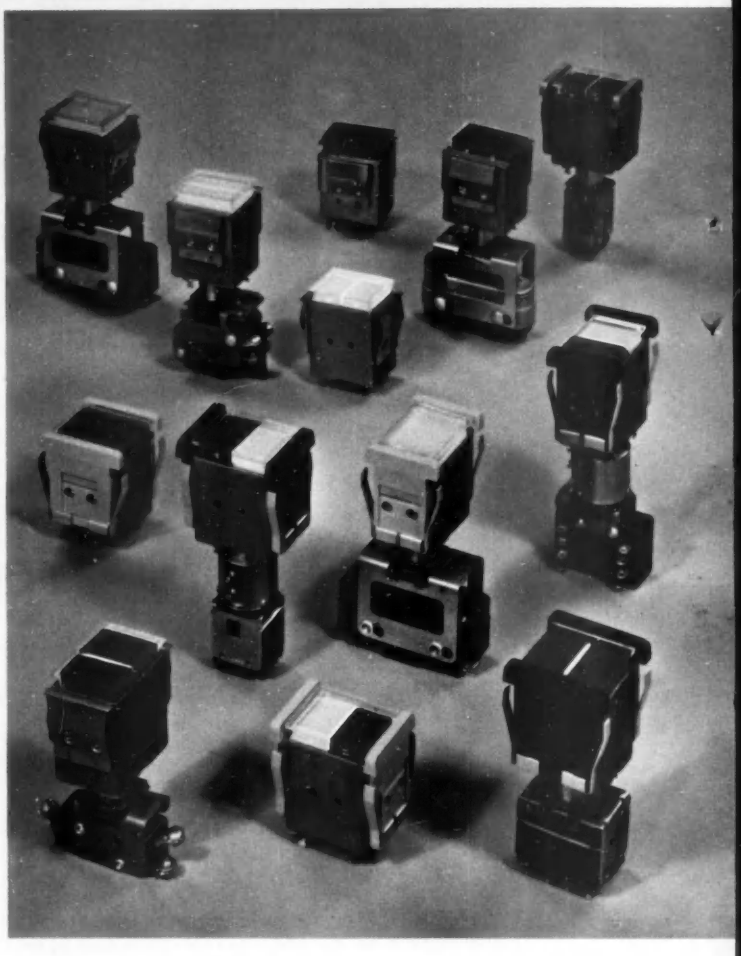
Assemblies built up of the desired number and type of units, snap into pre-cut rectangular slots in the mounting panels, *also without tools*.

Panels may be from 1/16″ to 5/16″ thick. Flange-mount units can be used with a mounting panel and overlay panel, or with mounting panel only.

Here is a new dimension of design freedom in illuminated switching equipment . . . an all-new system compatible with good human-factors engineering.

MICRO SWITCH Precision Switches

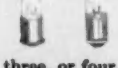
All new Series 2 lighted display and pushbutton switch devices offer new modular versatility in pushbutton switching



Yes, you can have the panel arrangement you want (preceding page) *and* the switch unit the application requires. At right you see a few of the hundreds of available combinations of Series 2 switch units and operator-indicator units. To attach an operator-indicator unit with a switch unit, just snap them together. All such combinations are available with or without magnetic d-c holding coil. Switch units are offered with switches from eight different MICRO SWITCH series of basic switches—"TB", "SM", "HS", Type "A", "MT", "DT", Type "Z", and "V3". Included are switches for low-energy circuits, switches for handling d-c loads of up to 10 amperes, 125 volts, and for direct control of a-c motors of up to two horsepower . . . alternate-action units, momentary-contact units, and units for control of multiple circuits.



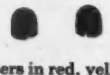
Display screen, in four colors and white. Also available split lengthwise or across.



Two, three, or four lamps can be used in operator-indicator or indicator units.



Operator-indicator unit, barrier type. Unit shown has long (side) barriers. Also available are short (end) barriers, and flange-type units without barriers.



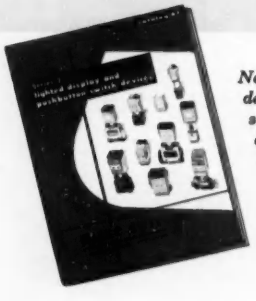
Color filters in red, yellow, green, or blue fit over lamps, permit projected-color lighting.



"SM" switch unit—one of many Series 2 switch units—snaps onto base of operator-indicator unit.



Indicator unit, long flange type. Short flange and barrier types are also available.



New Catalog 67 describes Series 2 devices in detail. Split pages aid selection of components. Contains detailed switch unit data and helpful ordering and color selection information. Sent free on request.

MICRO SWITCH . . . FREEPORT, ILL.
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH PRECISION SWITCHES

Purdue-CtE Conference:

Guidance Specialist To Outline Component Problems

The component problems facing missile and space scientists will be aired in an after-banquet speech at the 1959 Conference on Industrial Control System Components, co-sponsored by CONTROL ENGINEERING and Purdue University's School of Electrical Engineering and Division of Adult Education on May 4 and 5.

J. Allen Crocker of the National Aeronautics & Space Agency will describe some of the limitations of control components found by missile and space scientists and the difficulties caused by the shortcomings. In addition, he will point out areas in component development requiring urgent current effort.

At NASA, Crocker is program director, guidance and control, in the Office of Advanced Technology. He is heading up a program to establish a family of guidance packages compatible with the family of booster engines being created under NASA's direction. The object of the program: increased reliability of guidance and control systems through the repeated use of standard hardware instead of customizing systems for each space vehicle.

Before he joined NASA, shortly after it was officially formed last year, Crocker was assistant technical director of the Air Force's AFOAT-1 project—a program connected with the use of atomic power in aircraft. He had been a civilian engineer with the Air Force for 11 years.

• **An added starter**—One additional presentation—"Transistor Logic Circuity in Control Applications"—has been added to the program for the May Conference. A. M. DeSautels, senior development engineer in the Aeronautical Div., Minneapolis-Honeywell Regulator Co., will discuss logic circuit principles as applied to switching circuitry and logical decision and digital devices in control.

In his paper, DeSautels will also present a summary of Boolean algebra, a description of some typical logic circuits and a brief consideration of NOR logic and its use in logic circuitry.

Complete program of the meeting is tabulated below (for abstracts of the presentations, see CtE, March '59, p. 31). The conference, concerned with the application of components to industrial control systems, will be held at Purdue University's new Memorial Center located in West Lafayette, Indiana.



J. A. Crocker

Reviewing the program, Purdue's Dr. John E. Gibson, associate professor of electrical engineering, observed that the conference will explore the application of new components.

Registration fee for the two-day conference has been set at $35, which includes admission to all sessions, a copy of the proceedings and a banquet dinner on Monday evening, May 4. For additional information, write Merle M. McClure, assistant director, Div. of Adult Education, Purdue University, Lafayette, Ind.

PROGRAM

Conference on Industrial Control System Components

I. ACTUATORS (Monday morning)

Integral HP dc Servomotor Developments
by V. R. Murphy
Mgr. VS and Control Prod. Dept., Reliance Electric & Eng. Co.

Selecting Variable Displacement Hydraulic Pumps
by R. Spencer
Assistant Chief Engineer, Machinery Hydraulic Div., Vickers, Inc.

The Power Stepping Motor as a Digital Actuator
by W. R. Gracey
Mgr., Automatic Control Div., The Teller Co.

II. POWER AMPLIFIERS (Monday afternoon)

High Pressure Pneumatic Systems for Industry
by A. E. Schmidlin
Mgr., Research Dept., Walter Kidde & Co.

Using Magnetic Amplifiers in Control
by Dr. C. Wakeman
Director of Research & Development, Magnetics, Inc.

The Capstan-Type Mechanical Power Amplifier
by L. A. Zahorsky
Avionics Dept., Armament Div., Universal Match Corp.

Characteristics of the Acceleration Switching Servo
by Dr. W. Seamone
Applied Physics Laboratory, Johns Hopkins University

III. TRANSDUCERS (Tuesday morning)

Characteristics of Position Measuring Transducers
by J. O. Morin
Project Engineer, Concord Control, Inc.

Multipurpose Technique: Measuring with Eddy Currents
by Richard Hochschild
President, Metrol, Inc.

Transducers for Dynamic Flow and Measurement
by Dr. C. K. Sledman
Consultant, Statham Instruments, Inc.

How to Pick and Use Proximity Switches
by J. M. Morgan
Mgr., Development Research Dept., The Cincinnati Milling Machine Co.

IV. LOGIC ELEMENTS (Tuesday afternoon)

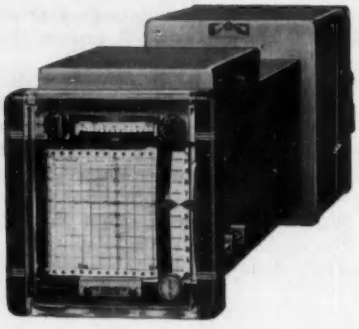
Building Blocks for Automatic Test Equipment
by J. J. Brett
Chief Engineer, Chicago Div., American Bosch Arma Corp.

The Controlled Rectifier — A New Industrial Control Concept
by E. E. Von Zastrow
Application Eng., Semiconductor Prod. Dept., General Electric Co.

Transistor Logic in Control Applications
by A. N. DeSautels
Senior Development Engineer, Aeronautical Div. Minneapolis-Honeywell Regulator Co.

AC — dc

this year more than ever in process control



The past year has been revolutionary. Electronic process control has won universal acclaim on every consideration: simplified installation . . . reduced maintenance . . . and, most important, better control performance. The evidence was so conclusive that other systems were totally ruled out on many new installations.

Swartwout pioneered electronic process control so Swartwout had a definite advantage: it was free to select the ideal circuit. AC in the measuring circuit has given unmatched simplicity and reliability extending the lengths and heights of the processing plant. DC is rightly used for the actuator. Experience has borne out the wisdom of this selection.

Moreover, Swartwout has shown that this vastly better control can be furnished without increased cost over pneumatic systems.

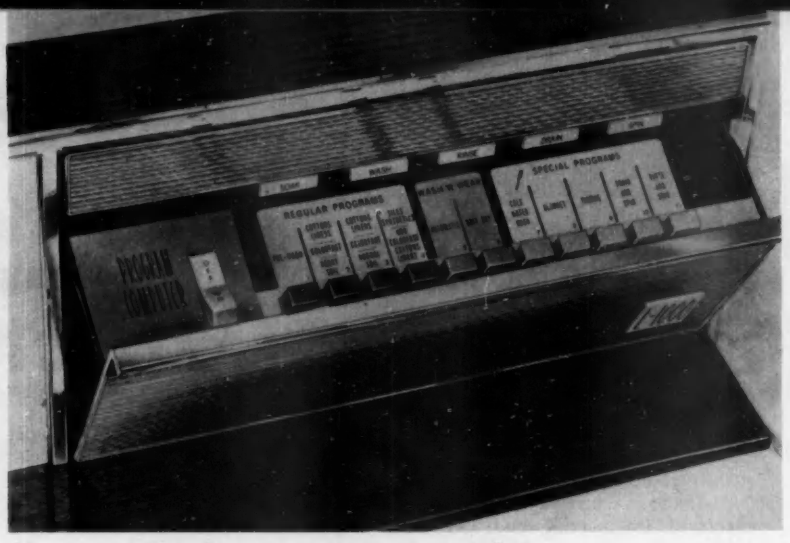
Send for Bulletin Series A-801. The Swartwout Co., 18511 Euclid Avenue, Cleveland 12, Ohio.

SWARTWOUT

. . . world leader in electronic process instrumentation

S-A. 1940

CIRCLE 32 ON READER-SERVICE CARD



Complex process computer-controller?
No, it's the control panel for a new home-laundry machine, system engineered.

What's Happening to Home Laundry Controls?

Some of the new control techniques — and semantics — are reaching into the appliance industry. Do they make chores easier or harder for the housewife?

CHICAGO—

At the International Home Furnishings Market in Chicago, buyers watched a demonstrator operate a new home-washing machine. The operator studied the kind of laundry going into the machine, thought for a second, then pushed one button on the computer-like console. The machine emitted a clacking, like the sound of a hard-working electromechanical data logger. Finally that stopped, and the washing cycle started.

This latest evidence of what is happening to appliance control was the Cycle-Set Power Timer, developed for automatic washers and dryers by Controls Co. of America. It is a prime example of CCA's new "control systems approach", which involves engineering the control system for a specific manufacturer instead of selling components to a laundry-machine builder that has already done the engineering.

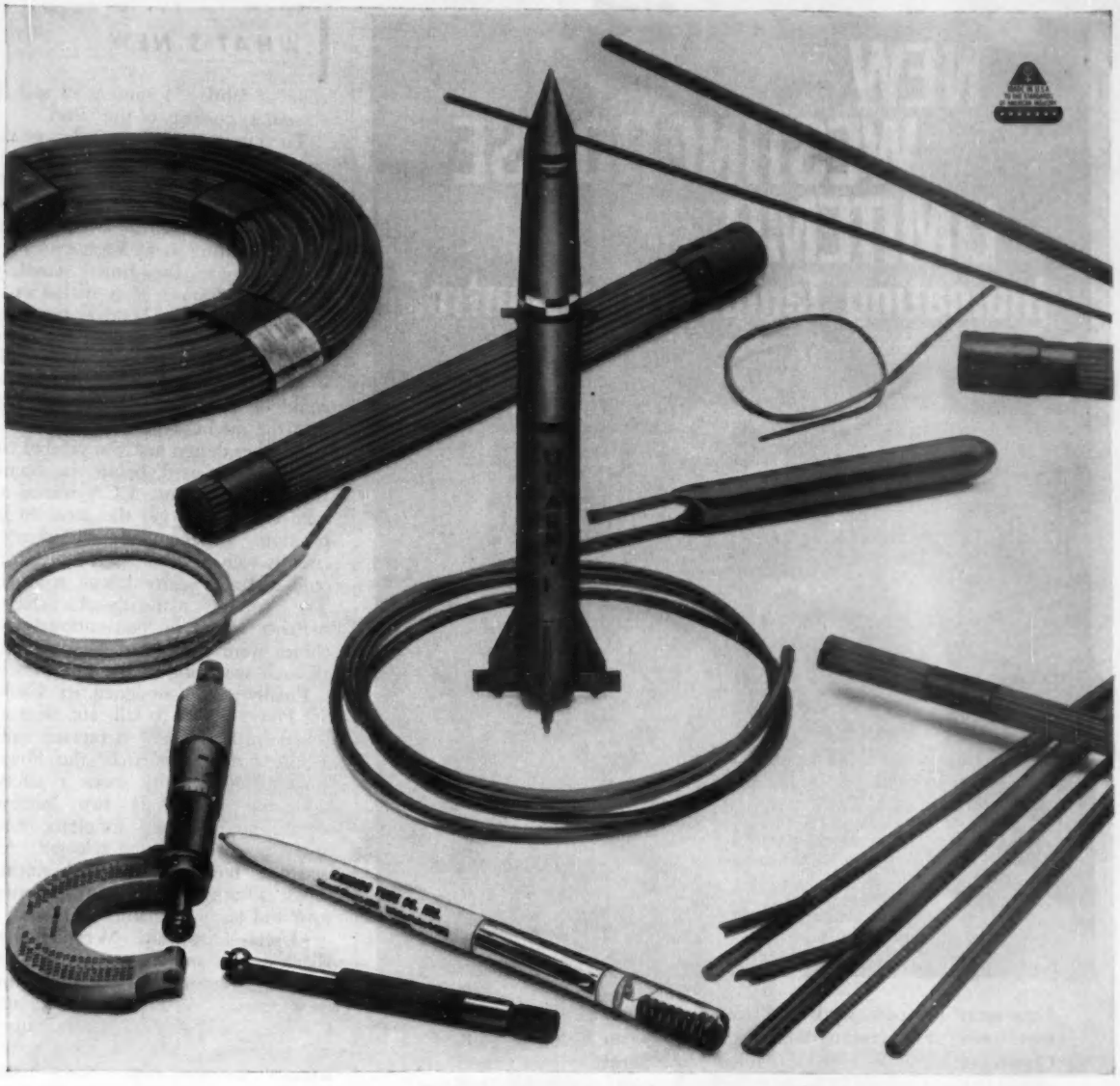
Basically, the new device is a timer driven by a servo to a preselected position. By pushing only one button, the housewife supposedly accomplishes everything that ordinarily requires pushing several buttons after studying a control panel.

• **Leading up**—The home laundry equipment industry has been leading up to something like this ever since Bendix brought out the first automatic washer in 1937. The pioneer Bendix featured a four-cam timer and switch for a one-cycle operation. During the period right after World War II, the home-laundry equipment manufacturers really gave automatic equipment a push. They provided additional water-temperature control: first hot and warm; then hot, medium, and warm; then hot, medium, warm, and cold; and finally hot, medium, warm, cool, and cold.

One 1958 automatic washer had 10 cams and five switches with as many as five positions, a console "like a B-29, and almost requiring an engineering degree on the part of the housewife to operate it", according to a CCA spokesman.

A good deal of the increasing complexity was due to the development of synthetic fabrics requiring special handling. The so-called wash and wear fabrics, for example, will wrinkle unless subjected to a special cooling-off period in the drying cycle.

• **Applying the systems approach**—Thus the stage was set for development of the Cycle-Set Power Timer. CCA started by considering four specific conditions: 1) type of fabric, 2)



EVER REALLY EXPLORE INNER SPACE?

Inner space of copper Capillary and Restrictor Tubing, that is? Especially that used for instrumentation and controls? Kensico recently asked an independent consulting service to explore the inner space of its small-diameter, *precision-drawn* tubing in comparison with leading competitive products. Some mighty revealing discoveries were made by using *photomicrography!* Interested control engineers may obtain a set of these photomicrographs—or Free Flow Charts and engineering consultation—by simply calling, writing or wiring Gordon Edwards at the Mt. Kisco plant.

We also make hard and soft copper water tube . . . copper air conditioning and refrigeration tubes . . . copper tubing for propane gas lines, heat exchangers, automotive and industrial applications.

CAMBRIDGE, MASS. · BUFFALO, N. Y. · LINDENHURST, N. Y. · GOSHEN, N. Y. · ROSELLE, N. J. · PHILADELPHIA, PA. · PITTSBURGH, PA. · CLEVELAND, OHIO · DETROIT, MICH. · EVANSTON, ILL. · ST. LOUIS, MO. DURHAM, N. C. · FT. LAUDERDALE, FLA. · ST. PETERSBURG, FLA.

Kensico Tube
COMPANY INCORPORATED, MT. KISCO, N. Y.

CIRCLE 33 ON READER-SERVICE CARD

NEW WESTINGHOUSE LIMITEMP
Indicating Temperature Control



Limitemp* is a new, medium-priced control device that is ideal for monitoring or controlling temperatures between 100° F and 400° F. Controller may be used to indicate temperature and sound an alarm if temperature exceeds the preset point. A few applications include windings of large rotating machines, bearings, process temperatures and controlling temperatures in critical areas such as nuclear controls.

Limitemp employs magnetic and semiconductor elements of proven reliability; therefore, no vacuum tubes, no moving parts, no contacts . . . nothing to wear out.

LIMITEMP CHARACTERISTICS:
INPUT: 115 volts, 60 cycles OUTPUT: 24 volts d-c at 5 watts
TEMPERATURE RANGE: 100° F to 400° F—40° C to 200° C
INDICATION: Dual-scale calibrated meter and pilot light
ACCURACY: Setting ±1%, indicating ±2%, bandwidth 2% of range
COMPACT: 4 in. wide, 8½ in. high, 6 in. deep

GET ALL THE FACTS . . . write Westinghouse Electric Corporation, Director Systems Dept., 356 Collins Avenue, Pittsburgh 6, Pa. Complete information on the new Westinghouse Limitemp will be sent to you by return mail. J-01008

*Trade-Mark

YOU CAN BE SURE . . . IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

CIRCLE 34 ON READER-SERVICE CARD

WHAT'S NEW

color of fabric, 3) amount of soil involved, 4) quantity of the "load".

To transmit this knowledge to the controls for a single pushbutton operation, CCA had to find a means of remotely operating the timer, integrating several manual switches, and accommodating many wash cycles.

To operate the timer remotely, CCA tried a simple servo with a small shaded-pole motor. It drives the timer rapidly to a predetermined angular position. Since automatic washers use a multiple-interval timer, the servo could be conventionally incorporated into the ratchet-type drive.

Another design first was printed circuitry—never used before in home-laundry equipment. CCA turned to such circuitry to get the servo to its position. The company said printed circuits were well-suited for the job—only a 1-amp current was required. The several manually-set selector switches found on conventional machines were eliminated by designing all such switching in the timer itself.

Finally, CCA designed its Cycle-Set Power Timer to fail safe. If a selected button is not depressed sufficiently enough to latch, the Power Timer automatically seeks a safety-shutdown point. If two buttons should be depressed simultaneously, only one cycle will be selected. All machine power is removed during rapid advance to prevent internal wear and tear in machine parts.

• **Users**—Thus far, Westinghouse Electric Co. and Sears, Roebuck & Co. are using the Power Timer on their deluxe 1959 home-laundry lines. CAA is working on similar control systems for a number of other home-laundry manufacturers. Sears home laundry line, marketed under the Kenmore name, is made by Whirlpool.

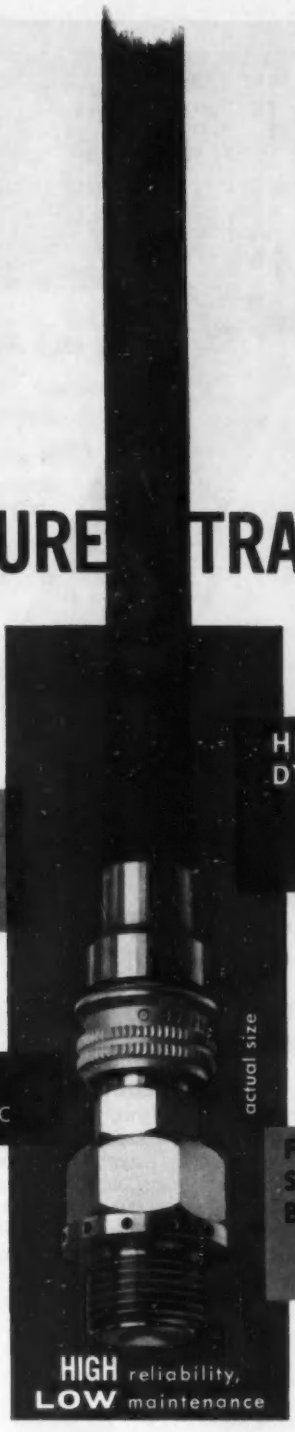
The Kenmore washer equipped with Cycle-Set Power Timer retails for $299.95, which is $40 more than the second most expensive model, but it contains several other deluxe features. The less expensive model will do everything the deluxe model will do, but the operator is required to dial-set the controls after consulting a billboard-type console.

• **Housewives' lament**—But not everybody is so sure that such sophisticated control belongs on a home appliance. Housewives, they claim, already have trouble keeping the vacuum cleaner, TV set, and other home appliances operating. So a couple of big appliance makers are holding back until they see how CCA's new control is accepted.

Sears, on the other hand, doesn't

NC CONTROLS

PRESSURE TRANSDUCERS



HIGH DYNAMIC RESPONSE
natural frequency 50 kc
damping constant
(cooled) .2

BONDED STRAIN GAGE RUGGEDNESS
2000 cps vibration and 1000 g
acceleration any axis

AIR or WATER COOLING
gas temperature 5000°F .11 BTU/IN²/SEC

FOUR-ARM 350 Ω STRAIN GAGE BRIDGE
also 2 arm 700 and
1000 Ω bridges

all-welded diaphragm for corrosive applications

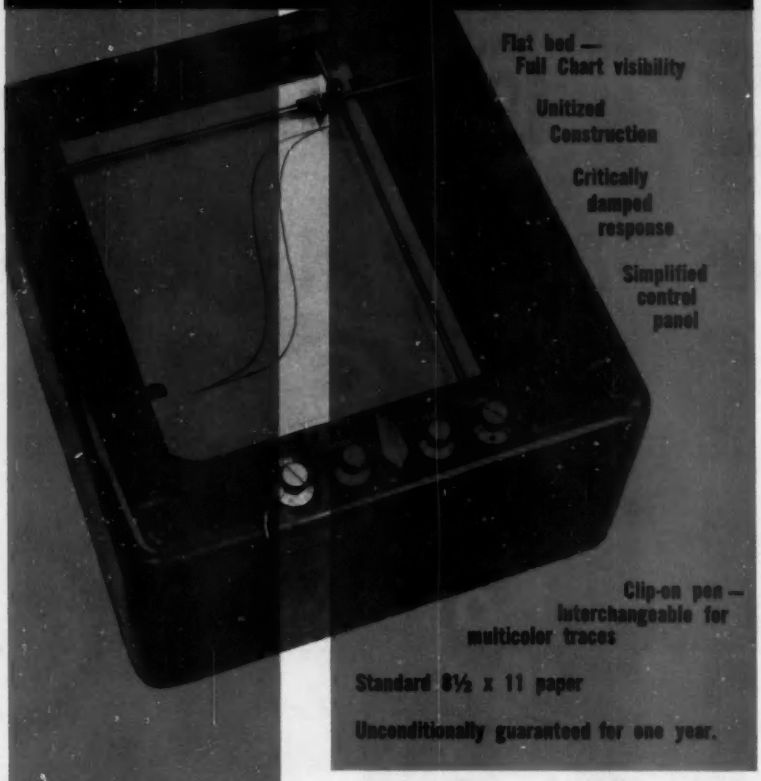
HIGH reliability,
LOW maintenance

Write for Data Sheets covering Norwood Controls Transducers . . . Norwood Controls Unit, Detroit Controls Division, 938 Washington St., Norwood, Mass.

AMERICAN-Standard
DETROIT CONTROLS DIVISION

CIRCLE 35 ON READER-SERVICE CARD

HR-92 X-Y
RECORDER



RUGGED "All Purpose" X-Y RECORDER

The HR-92 is a null-seeking servo-type plotter designed to draw curves in Cartesian coordinates on regular 8½ x 11 graph paper. It employs conventional chopper amplifiers, 2-phase motors and a potentiometer rebalance. Reference voltages are furnished by mercury cells. Control panel has zero set and continuously-variable attenuator for each axis. Separate standby and power switches are provided. The two axes are electrically and mechanically independent. By moving an internal jumper lead, a high impedance potentiometer input can be made available.

SPECIAL FEATURES:

- Amplifiers easily removed if servicing ever becomes necessary. Electrical connections all contained in two plugs for each amplifier.
- Each amplifier channel (including transformer power supply) independent of rest of system.

WRITE FOR:
New X-Y Recorder Circular #717-3 showing complete specifications and photographs.



houston instrument corporation
1717 Clay Avenue • Houston 3, Texas
CA 5-6964

CIRCLE 36 ON READER-SERVICE CARD

WHAT'S NEW

expect any additional service difficulties. In fact, the company is counting on the new control cutting down service calls. Sears has had, however, to step up its field service training program.

Last November, in cooperation with Whirlpool, the company sent out seven crews of men equipped with slide films, engineering drawings designed for the servicemen, samples of the console, and various other information. They are still making the rounds in larger cities, training local servicemen. Field supervisors train store servicemen in smaller towns.

But if housewives were awed by the new Cycle-Set Power Timer on home-laundry machines, even bigger —and more complex—things are ahead. Hotpoint, at the same furnishings show, unveiled a programmed kitchen. Slipping one 4 in. by 4 in. punched card into a master control is all the housewife has to do to prepare an entire meal. The card automatically determines how long each item is cooked, sounds a buzzer when the entire meal is ready.

—Stewart Ramsey
McGraw-Hill News

Transistor Tester . . .

. . . makes up to 18 go/no-go tests, sorts into 10 separate categories. The concept looks promising for solving other testing problems.

DALLAS—

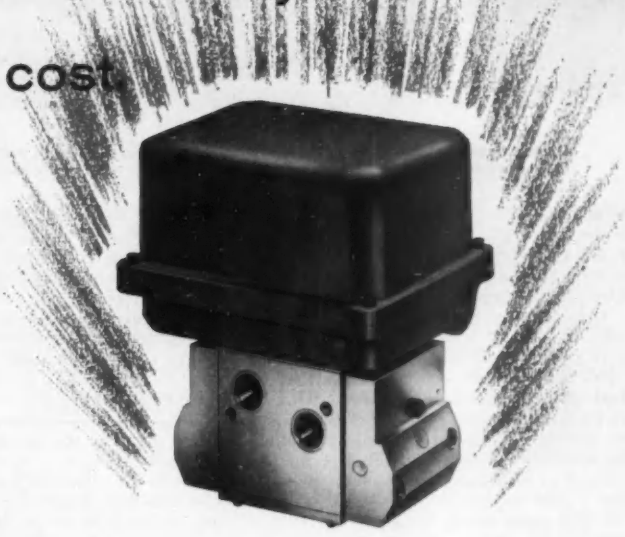
A semi-automatic testing machine puts transistors through up to 18 different tests, sorts them into 10 separate categories—handling up to 1,200 transistors per hour. The Centralized Automatic Tester (CAT), working since early 1958, was built by the Industrial Instrumentation Div. of Texas Instruments for use by TI's Semiconductor Div. Now TI plans to sell CAT to other companies with testing problems.

To use CAT for transistor testing, the transistors are manually loaded into test blocks along with a punched card. After that, testing operation is completely automatic. The transistor (with its punched card) moves down a straight line through up to 18 go/no-go tests, about 6 in. apart, then past 10 sorting stations.

At each test station, information obtained during the test is punched onto the card. A mask and photocell reads the card at the sorting stations.

A test cycle lasts 3 sec: 1½ sec for

GPE Controls, Inc. presents an outstanding new advance in industrial automatic controls...the Rotojet® series of **electro-hydraulic servo valves.** Electrical input specifications include all ranges in current use. Total hysteresis is less than 0.2%. Single-stage output of 4½ g.p.m. at 1000 p.s.i. matches or exceeds most 2-stage units. Frequency response is 32 c.p.s. No filtration necessary. Guaranteed reliability at lowest cost.



GPE Controls | A GENERAL PRECISION COMPANY

Write for descriptive literature

GPE Controls, Inc. (formerly Askania Regulator Company)
240 East Ontario Street • Chicago 11, Illinois

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

CIRCLE 37 ON READER-SERVICE CARD

NEW BENDIX DRIVER TRANSISTORS



AUDIO AMPLIFIER (CLASS A OR B) • AUDIO OSCILLATOR • POWER SWITCH TRANSISTOR DRIVER • SERVO CONTROL • RELAY DRIVER • MOTOR CONTROL

Slated to be the "workhorse of the transistor industry", this new Bendix series consists of three models—each with a different voltage rating and each in high-volume production.

Contained in the JEDEC TO-9 package, this tiny transistor dissipates 400 mW of power at 25°C and 67 mW at 75°C. The higher voltage rating and high current gain are combined with more linear current gain characteristics to enable switching applications and lower distortion output. Featuring low saturation resistance, the typical values are 1 ohm measured at 100 MA. The 2N1008 series has a minimum current gain of 40 and a maximum of 150.

Eliminating the internal connection between transistor and case allows circuit isolation. Long life and stable operation are assured by welded construction and a vacuum-tight seal.

ABSOLUTE MAXIMUM RATINGS

	Vce Vdc	Ic mAdc	Pc mW	Ib mAdc	T Storage °C	Tj °C
2N1008	−20	300	400	30	−65 to +85	85
2N1008A	−40	300	400	30	−65 to +85	85
2N1008B	−60	300	400	30	−65 to +85	85

Write today for the new Bendix Semiconductor Catalog for more information on our complete line of power transistors, power rectifiers, and driver transistors. SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, N. J.

West Coast Sales & Service: 117 E. Providencia Ave., Burbank, California • Midwest Sales Office: 4104 N. Harlem Ave., Chicago 34, Illinois • New England Sales Office: 4 Lloyd Rd., Tewksbury, Mass. • Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. • Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario.

Red Bank Division — Bendix AVIATION CORPORATION

CIRCLE 38 ON READER-SERVICE CARD

transistor testing and information readout to the punches, 1½ for advancing the line of test blocks. While the line is advancing, a standard resistor is substituted into each test circuit for a calibration check.

Since the calibration resistor is calculated to be a borderline reject, if it does not test out as such, the main control is stopped, and an indicator light shows the defective test station. The same cycle also tests the lamp, photocell, and photocell amplifier in the readout stations.

At the start of the testing line, transistors move through three pretest stations to spot transistors of the wrong type, shorted or punched-through devices, or transistors plugged into test blocks backwards.

Determination of reject limit for each test is accomplished with a null-detector in either a current or a voltage bridge. Standard adjustable voltages or currents are supplied by a plug-in unit containing mercury cells.

Transistors that have not been sorted into one of the 10 established groups are automatically removed from the test block at the end of the test track. Punched cards are also automatically removed from the test blocks and discarded. The blocks then return to the beginning of the line to receive new transistors and cards.

Each test station has the same capacity as four hand-operated test sites. Using three or four semi-skilled women as operators.

By means of test circuits built into plug-in cans, TI has made CAT flexible. It is easy to change test conditions and to make necessary repairs.

Computer-Controller to Improve Sun Oil Processes

A joint developmental and investigative venture has been launched by Sun Oil Co. and the Genesys Corp. as part of a program to improve the efficiency of existing plants with optimum control systems. The first system is to be applied to the heavily instrumented Number 12 plant at Sun's Marcus Hook refinery.

The announcement revealed the first application of the Genesys Corp. system (See CtE, Nov. '58, p. 18, for a brief description), which uses an incremental digital computer with a disc memory. Other computing-control projects in the process industries have used analog or general-purpose digital machines.

ALL ICBM'S USE . . .

MOOG: servoactuators . . .



. . . in their rocket gimballing systems

Moog servoactuators are compact, lightweight package units that typically include an actuating cylinder, servovalve, and feedback sensing device. These integrated units offer the advantages of a comprehensive custom design including reduced complexity and retaining high performance. Additional special features can be incorporated to meet particular applications.

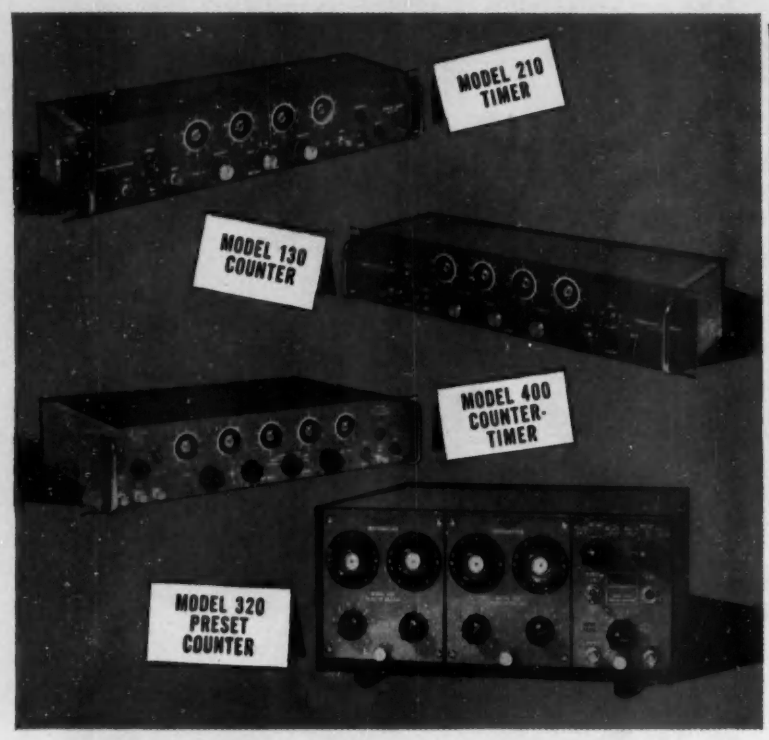
In addition to ICBM and other missile, rocket, and aircraft applications, Moog servoactuators can function wherever rapid, accurate, high force positioning is essential in an electro-hydraulic system.

For complete details on Moog servoactuators write for Catalog 170.

MOOG VALVE CO. INC.

PRONER AIRPORT, EAST AURORA, NEW YORK

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- Truly Simplified Digital Instrumation

TIMER—Model 210: The "electronic stopwatch" for Precise Time Interval Measurement with ±0.005% crystal controlled accuracy. Non-critical controls. Price $395.00

COUNTER—Model 130: A lightweight (12 lbs.), compact, moderately priced, general purpose digital frequency counter with high sensitivity (25 mv r.m.s.). Price $395.00

COUNTER-TIMER—Model 400: Precision and versatility combined in a unique general purpose Universal counter-timer, with .001% crystal stability, electronically regulated D.C. power supplies and a unique gating circuit. Price $695.00

PRESET COUNTER—Model 320: Modularized preset counter available in any combination—single or dual—2 through 6 digits. Photocell input and output modes. Priced from $375.00 to $695.00

For detailed information and specifications write or telephone.

ERIE *Instrumation*
ERIE-PACIFIC DIVISION
ERIE RESISTOR CORPORATION
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CIRCLE 40 ON READER-SERVICE CARD

WHAT'S NEW

GE Eyes Computing-Control Market

General Electric announces a computer-controller for the process industries, built around a general-purpose digital machine. Flexibility is the key word.

PHOENIX—

At its sun-drenched Computer Dept., General Electric last month unveiled its entry in the race for the process-computing-control market: the GE 312 computer-controller. The 312 is designed to solve a wide variety of real-time process-control problems in the gas and electric utilities, and the chemical, petroleum, petrochemical, and metal processing industries. To-date, the company has sold two units; both are going into steel rolling mills.

In designing the 312 system, GE engineers strove for maximum flexibility. Major characteristics include an expansible memory, flexible speed and programming potential, and a wide and diversified range of input and output capabilities.

GE plans to market its process-control equipment as two related systems: the 311 and the 312. The former is a data-logging and process computing system that, on line, permits the user to perform statistical analysis and develop operating guides. The latter is for closed-loop control.

If a buyer, say GE executives, purchases a 311 system and then decides to close the loop, he can expand his system into a 312 system by adding the desired control components, available in modular form. Both systems use the same computer, what GE calls model 312.

• **Digital heart**—The computer itself is completely solid state, operation is serial, single or one plus one address. Word length is 19 binary digits plus one sign bit.

The digital machine offers the following options:

▶Memory—The memory unit is a high-speed (4,800 rpm) magnetic drum. Memory capacity is 2,048, 4,096, 8,192, 12,288, or 16,584 words.

▶Speed—Basic clock rate is 250 kc per sec. But a number of possibilities are available to increase the speed of operation:

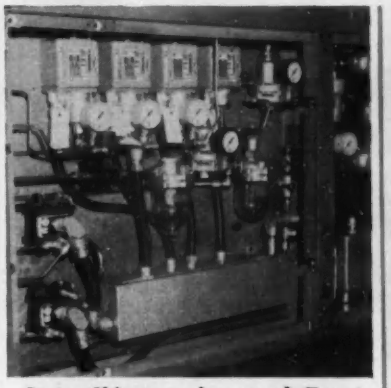
Optional use of revolvers—high-speed recirculation loops—to reduce drum access time.

Addition of special-purpose computers to operate concurrently with,

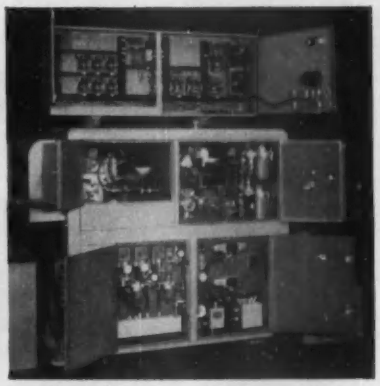
Skinner solenoid valves solve many different cylinder control problems



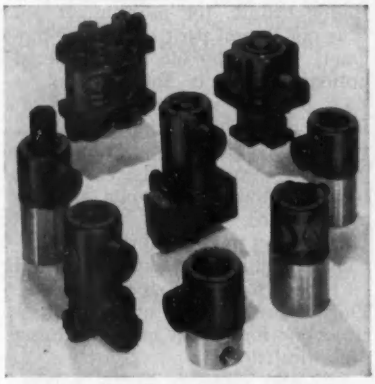
Application. This Bryant "Centalign" automatic internal grinder is an entirely new concept in precison grinding machinery. Work parts are gravity-fed through chutes and loaded to grind position automatically. Centalign design permits higher, more accurate production at lower cost in the grinding of straight or tapered bores or forms such as ball tracks.



Seven Skinner valves used. Four-way, V9 valves control cylinders actuating work ejector, work interceptor and work loading chute. Others control cylinders for activating a diamond holder for wheel sizing; an oscillator for grinding; and a compensating cylinder to skip wheel dressing action. Still another controls the shop-air supply to the machine.



Adjustable flow features of the four-way valves permit split-second adjustment of cylinder action. And all the valves are small, compact and easy to mount at any angle. Built-in spring returns assure positive closing. Such features enable Bryant to manufacture the Centalign in panels that afford easy access to all pneumatic, hydraulic and electric circuits.



A complete line. There's a Skinner solenoid valve for almost any flow application with a wide variety of media: air, oil, water, inert gases, hydraulic fluids, kerosene and gasoline. Orifice sizes range from 3/64" to 1". Pressure ratings range from 5 psi to 3000 psi. Explosion-proof models are UL approved for Class 1, Group D and Class 2, Groups F and G.



100,000 variations. The Skinner valves used by Bryant are so versatile in design that standard models can be used for applications normally calling for specials. Skinner solenoid valves are engineered to have a life expectancy of millions of trouble-free cycles.



Quality assured. Electrical tests to UL Standards include resistance check of coils in valve; breakdown check of 2x's rated voltage plus 1,000 volts; heat rise check of continuously energized coil for operation not above 85°C (185°F) rise above room temperature. These tests assure that you can use Skinner solenoid valves with confidence.

Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept 344.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

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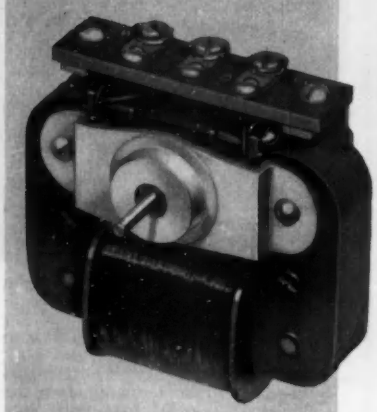
THE MARK OF QUALITY

BARBER COLMAN

a-c small motors

low cost..rugged and accurate...

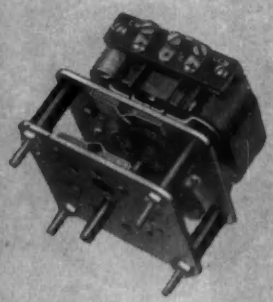
a-c tachometer generators



Here's a design tip that can save you money with no compromise in product quality! Barber-Colman reversible motors perform efficiently as dependable a-c tachometer or rate generators. Voltage is nearly linear in the range of 1000 to 3000 rpm and is usable beyond these speeds with but slight additional loss of linearity. Generated voltage is of the order of two volts per thousand rpm and can be increased to the order of 10 volts per thousand rpm with shading coils of higher impedance. Write for Bulletin F-9256 with performance curves.

low cost...reversible

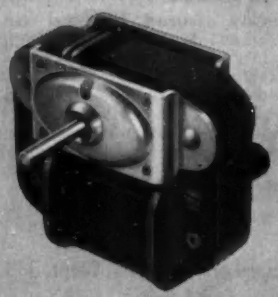
servo motors



Compact, powerful . . . for servomechanisms, remote switching and positioning devices, recording instruments, voltage regulators. Adaptable to a variety of control circuits (including control from vacuum tube and transistor amplifiers) for power requirements up to 1/25 hp. Write for Catalog R1.

low cost...unidirectional

blower motors



High-quality, precision-made motors that give long, trouble-free service for driving blowers and fans. Low noise level . . . long-life alignable bearings . . . large oil reservoirs . . . high starting torque. Ratings up to 1/20 hp. Write for Catalog U1.

BARBER-COLMAN COMPANY

Dept. P, 1248 Rock Street, Rockford, Illinois

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls
Electrical Components • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

CIRCLE 42 ON READER-SERVICE CARD

WHAT'S NEW

and be dispatched by, the 312 computer.

T. H. Lee, GE consulting analyst, explains what this last feature can mean. For a steel-mill application, says Lee, the customer wanted strip-metal defects in a processing line recorded on each foot of strip. The request imposed a heavy computing load on the system, so GE added special-purpose hardware to do the job, recording once every 8 ft of strip. The accumulated defect information was then transferred from the special-purpose computer to the 312 for processing and statistical analysis.

According to Lee, special-purpose analog computers, digital computers, or digital differential analyzers can be added to the 312 computer, and operated as a single system. GE provided a surplus of control and communication paths, says Lee, because it wanted to build broad possibilities into the system.

• **Programming made easy**—By incorporating a series of automatic aids, GE has made its computer-controller relatively easy to program. One outstanding help: a scientific computer simulator program. Using a computer's timing feature, the programmer can time out critical parts of the 312 program. Users who incorporate special options will also be able to check on their proposed machine before making modifications to the factual 312 system. GE plans to distribute the programs throughout the country so that a customer can debug his own program close to home.

One other programming aid, microcoding, permits the planner to expand on the machine's 60 basic commands. Programmer can make up scores of instructions for special needs by using sophisticated techniques.

GE also plans to supply a complete subroutine library, will make available assembly and optimizing routines and diagnostic programs that tie into a user's regular production programs.

Another unusual feature of the machine is an index register that provides an immediate access system for counting and storage purposes. This permits, says GE, a saving of 2 to 1 in storage requirements.

Prices for the new system are not yet firmed. GE spokesmen estimate that a typical 312 system for closed-loop control will cost between $150,000 and $500,000. The 311 system: $100,000 to $250,000, including input-output equipment.

—Michael Murphy
McGraw-Hill News

Pilot Data Processor . . .

. . . contains three independently programmed computers. It's being built to solve a broad variety of problems, ranging from business applications to closed-loop control.

WASHINGTON—

Nearing completion at the National Bureau of Standards is a unique network of computers, put together to simulate a variety of data-processing systems. The logical design of the new machine, called PILOT, provides for exploring four kinds of applications:

▶ business-type data-processing applications. The system performs accounting, record-keeping, and information retrieval operations for management purposes.

▶ scientific data-reduction applications. The system performs complicated mathematical and logical manipulations on the data.

▶ control applications. The system is used for real-time control and simulation operations in conjunction with analog computer facilities or with automatic instrumentation facilities—remotely located, if necessary.

▶ data-processing network applications. The system communicates with other digital computer facilities to form a communication network in which all the computers collaborate on large-scale problems that are beyond the capacity of one machine.

• **How it works**—PILOT contains three independently programmed computers, each specially adapted for performing certain classes of operations which occur frequently in large-scale data processing. The computers intercommunicate in a way that permits all three of them to work concurrently on the solution of a common problem. Concurrent operation shortens the time required to solve large-scale problems. And each computer can work on the portion of the problem for which it is individually best suited.

Of PILOT's three computers, the primary and secondary ones each use only 16 basic instructions. Examples: add, subtract, multiply, shift, compare. Because so many variations of the word format are provided, a wide variety of operations can be performed with these few instructions. Both primary and secondary machines, acting cooperatively, can carry out special complex sorting or search operations.

The third computer, called the input-output format controller, specializes in editing, inspecting, and modifying information that is flowing into or out of the system. All three ma-

THE MARK OF QUALITY

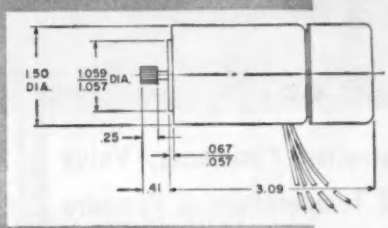
BARBER COLMAN

400-cycle motors for aircraft/missile applications



TYPICAL SPECIFICATIONS:

- Rated motor speed ... 10300 rpm
- Rated current ... .76 amp
- Rated horsepower ... .020
- Starting torque ... 0.3 lb-in.
- Weight ... .82 lb (exluding capacitor)
- Temperature range ... 65°F to + 250°F (per MIL-M-7969b)



Here is the precision Barber-Colman AYLO motor — designed for 400 cycle, 115V operation. Four-pole field . . . two balanced windings permit reversal with an SPDT switch . . . unit shown has 400-cycle brake which has a minimum life of 300,000 cycles. This motor has passed MIL-M-7969a qualification tests . . . motor life 1000 hours when tested per these specifications. Write for technical bulletin.



THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS includes: *D-C Motors* for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds . . . also available with gearheads or blowers. *Tach Generators* for accurate speed indication and servo rate control applications. *Choppers* that require extremely low driving power. *Resonant Relays* characterized by low operating power, narrow band width. *Ultra-Sensitive Polarized Relays* operating on input powers as low as 40 microwatts. *400 Cycle A-C Motors* for aircraft and missile applications.

TECHNICAL BULLETIN SERVICE on all Barber-Colman electrical components. Detailed specifications, performance data, circuitry drawings. Write for bulletins on any or all products.



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Dept. P, 1848 Rock Street, Rockford, Illinois

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FultroMatic Combines Controller, Positioner, Valve ...Gives Precise Control of Temperature or Pressure

Now, this lab-tested, field-proved FultroMatic answers today's precise control requirements with multiple features never before available in one unit . . . *at about half the cost of two- and three-unit systems!*

- **Improved accuracy** with smaller, faster-responding element.
- **Positive valve positioning** by feedback action; no overshoot.
- **Adjustable proportional band** easily changed on the job.
- **Simplified settings** with knob, indicator, arbitrary scale.
- **Field reversibility:** control action quickly changeable.
- **Easy to install:** place valve in position, mount bulb, connect air.
- **Low maintenance:** rugged design for trouble-free service.

FOR COMPLETE FULTROMATIC SPECIFICATIONS, WRITE FOR BULLETIN GW-755

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tennessee

CIRCLE 44 ON READER-SERVICE CARD

WHAT'S NEW

chines share common access to the high-speed internal memory, which is linked to the input and output external storage units via independent trunks.

PILOT will be able to transfer data concurrently along these input-output trunks. Only two are planned for the initial installation. With these, however, it will be possible to keep two continuous streams of data flowing simultaneously between any two external units and the internal memory, without interrupting the data-processing program.

• **High speed**—As a result of the unique logic design, the PILOT data processor should operate more than 100 to 1,000 times faster than SEAC (NBS' well-known computer). This means a rate comparable or better than most modern large-scale commercial computers, even though the basic digital repetition rate is only 1 mc. The arithmetic speed derives in part from the concurrent use of the machines and in part from connecting a novel type of parallel adder to a diode-capacitor memory capable of one random access per microsec.

Major building blocks of the system: 1) the primary computer, 2) the primary storage, 3) the secondary computer, 4) the secondary storage, 5) the input-output control, 6) the external storage, 7) the input-output units, such as readers, printers, and displays, and 8) the external control, containing the special features that facilitate communication with human operators and with devices external to the system.

• **Unusual features**—Because of its multiple design, PILOT has a number of unusual features. For example, it will have extremely flexible controls for communicating with the outside world. It can freely exchange information with human operators or with a variety of data-collecting instruments.

The system will also have a wide range of internal processing formats. These "built-in" formats will save time in programming problems.

NBS will use the new system for the experimental investigation of government problems. Main areas of work: helping to determine what areas in Federal agencies are adaptable to modern data processing; and then studying what kinds of available equipment are suited to such activities.

Logic design of PILOT was devised by A. L. Leiner, W. A. Notz, J. L. Smith, and A. Weinberger, all of the bureau's data-processing laboratory.

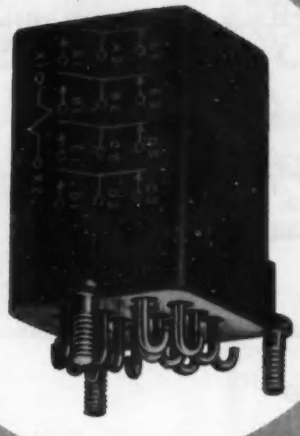
Three Allied Control Miniature

10 amp

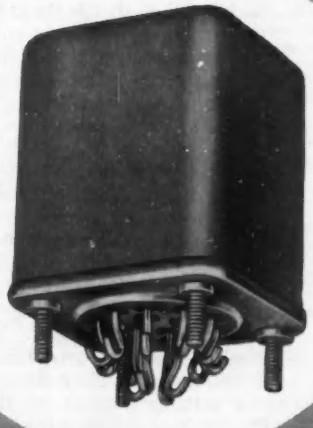
Relays



Type MHY



Type CH



Type PBH

These relays are designed to meet the rigid requirements of missile, aircraft and ground support equipment.

For complete information write for CH, MHY, or PBH Bulletin

GENERAL SPECIFICATIONS

	Type CH	Type MHY	Type PBH
Contact Form	4 PDT	4 PDT	2, 3 and 4 PDT
Contact Rating	10 amps resistive 8 amps inductive at 29 v d-c or 115 v a-c	10 amps resistive at 29 v d-c or 115 v a-c	10 amps resistive at 29 v d-c or 115 v a-c
Shock	100g	75g	50g
Vibration	30g up to 2000 cps	20g up to 500 cps	10g up to 500 cps
Temp. Range	−65°C to +125°C	−65°C to +125°C	−55°C to +85°C
Weight	5 oz.	4.2 oz.	6.5 oz.
Overall Dimens.	1 3/16 x 1 1/2 x 2 3/64	1 17/64 x 1 13/16 x 1 61/64	1 43/64 x 1 61/64 x 2 13/64

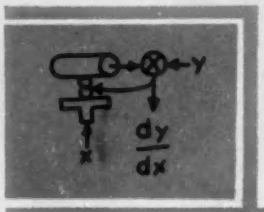
ALLIED CONTROL

ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, N. Y.

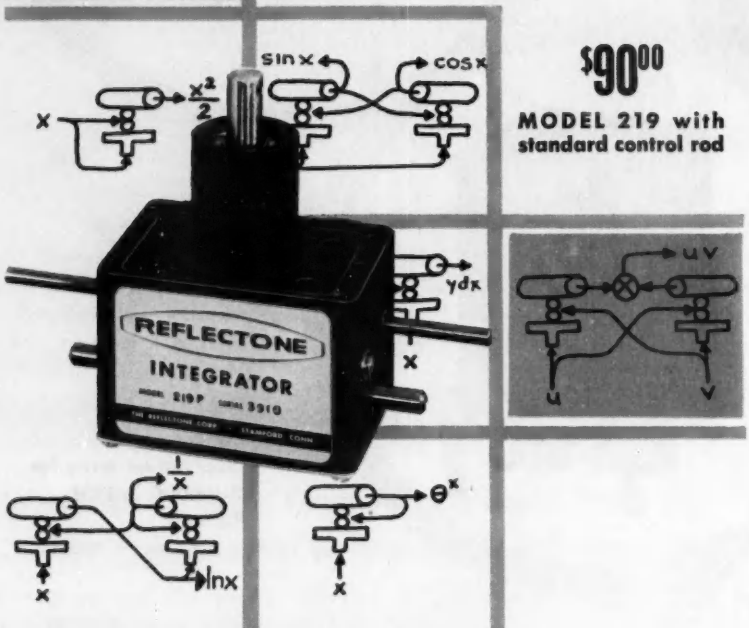
CIRCLE 45 ON READER-SERVICE CARD

AL-194

HIGH-PRECISION BALL AND DISC INTEGRATORS

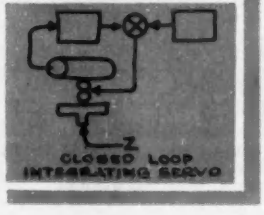


Highest accuracy and reproducibility for automatic control and computing systems. Smooth, reliable operation for precise speed control and accurate integration of variables such as flow, strain or position. Low-cost, compact, flexible design element. No lubrication required.



$90.00

MODEL 219 with standard control rod



TYPICAL APPLICATIONS

NAVIGATION SYSTEMS • FLOW TOTALIZERS • PRECISION SPEED CONTROL • PLANIMETERS • TACHOMETERS • CONTINUOUS WEIGHING DEVICES • STRAIN ANALYSIS • INFRA-RED SPECTROPHOTOMETERS • PROCESS CONTROLS

SPECIFICATIONS:

Accuracy:	±0.1%
Reproducibility:	±0.01%
Output Torque:	3 oz.-in. (higher outputs at reduced accuracy)
Input Torque:	2 oz.-in. (no output load)
Control Rod:	Vernier, rack, screw, or plain Special rods designed to specification
Control Rod Force:	3 oz. static 1 oz. dynamic
Backlash:	8 minutes at 2 oz.-in. and ½ inch control rod displacement
Input Speed:	0-750 rpm
Output Speed:	Reversible up to more than twice the input

Additional mechanical specifications and applications data available on request.

REFLECTONE

THE REFLECTONE CORP. • STAMFORD, CONNECTICUT

CIRCLE 46 ON READER-SERVICE CARD

EUROPEAN REPORT

Conference Proves an Instrument Industry Rises in Hungary

Budding Hungarian instrument makers hosted a measurement conference at which Soviet bloc countries trotted out some new techniques.

LONDON—

Before World War II, Hungary was one of the least industrialized states in Europe. But today, under Soviet prodding, Hungary is developing into the chief instrument maker for the Eastern bloc. Just how far the Hungarians have progressed was evidenced late last year, when Iron Curtain countries gathered in Budapest at an International Measurement Conference.

Sponsored by the Academies of Science of Hungary, Poland, and USSR, the conference was attended by 800 delegates—580 were Hungarian engineers. However, all the Soviet bloc countries were on the program, which emphasized the practical aspects of measurement. Here's a sampling of what the conference heard:

• **From Hungary**—Engineers A. Ambrozy and H. Tarnay described a technique for measuring continuously the thickness of lacquer on enameled wire. The approach: make the wire part of a capacitor. The wire, which forms one plate of a capacitor, passes through a column of mercury, which serves as the other plate. Variations of lacquer thickness then change the capacitance.

The actual instrument—over 40 of them are installed at the Albertfalva wire lacquering plant—uses four mercury columns in parallel; each can be switched to a central capacitance bridge. After a rotating plate capacitor has set the differential bridge to the desired thickness value, a dc output signal from a phase-sensitive detector indicates the amount and direction of deviation from specified thickness.

• **From East Germany**—An unusual optical method of measuring torsion in driving shafts was reported by K. H. Schulze. With a polarized light beam, he illuminated a glass disc cemented in a suitable position on the shaft. The resultant double refraction in the disc is detected by a photocell analyzer. Torsional movement of the shaft twists the refracted polarized light in the direction of the principal stress, sending to the photocell a light impulse proportional to shaft twist.

• **From Russia**—A new way to use magnetic nuclear resonance—to meas-

Where the switching job is big, but the space is small . . .

Specify . . . **THE ORIGINAL DOUBLE-POLE SWITCH WITH EIGHT CONTACTS.**
Makes possible a wide variety of circuit combinations.

- **THE ORIGINAL DOUBLE-POLE SWITCH WITH SIMULTANEOUS "MAKE AND BREAK" ACTION.**
  Reduces arcing, prolongs switch life, increases electrical capacity and permits unusual applications.
- **THE SMALLEST DOUBLE-POLE SWITCH.**
  Saves weight and space; allows more compact designs.



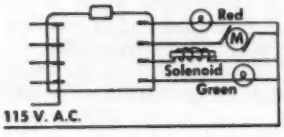
the original

ELECTRO SNAP

SIMULTANEOUS DOUBLE-POLE D8 SWITCH

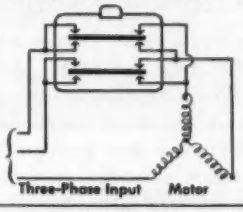
Look What You Can Do With It...

Control Four Circuits with ONE Snap



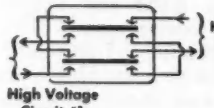
Used in motor control device at left, switch, when actuated, (1) turns off red pilot light; (2) completes circuit to motor winding, starting motor; (3) opens circuit to solenoid latch; locking door to motor gear box; and (4) turns on green pilot light.

Start, Stop, Reverse Three-Phase Motors



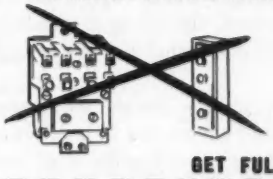
Because this new double-pole switch can simultaneously break or reverse current flow through *two* windings of a three-phase motor, you can use it as an inexpensive limit switch on three-phase lathes and drills. Use it to control automatic sequences, to limit motion of machine members driven by three-phase motors and as a start-and-stop switch.

Wire Movable Poles in Series to Switch High Current or High Voltage



As proof of simultaneous action, you can connect the two movable poles in series to increase contact area for high current applications and to increase number of contact breaks for high voltage switching.

Eliminate Expensive Relays and Additional Switches in Many Applications



This double-pole switch offers designers a wide variety of circuit hook-ups that were formerly possible only with complicated relays or a number of separate switches. Controlling three-phase motors is but one example.

Equip with Actuator



Push-button actuator may be added for panel mounting or for long overtravel. Switch is rated at 15 amps 125/250 v. AC or 10 amps inductive, 30 v. DC. Case dimensions are only 1½" x ⅞" x ½". Weighs only 20 grams.

GET FULL DATA

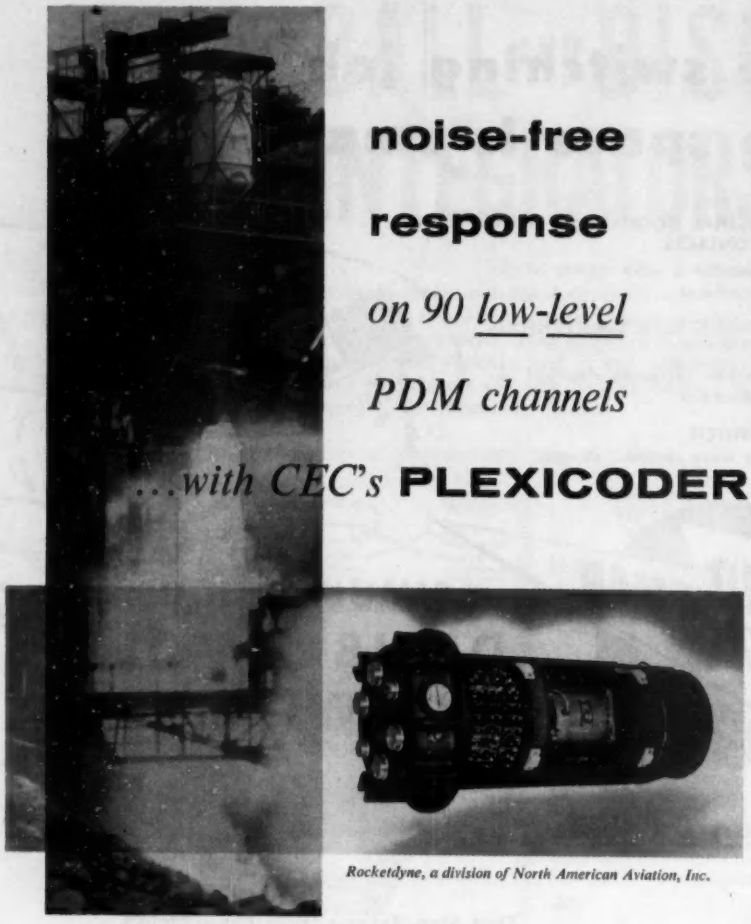
ELECTROSNAP CORPORATION
4248 West Lake Street
Chicago 24, Illinois

Please send full information on the original Electrosnap D8 Double-Pole Switch to:

Name_____
Title_____
Company_____
Street_____
City_____ Zone____ State_____

OTHER ELECTROSNAP PRECISION SWITCHES

Standard Basic Switch · **Immersion-Proof Switch** · **Hermetically-Sealed Switches** · **Sub-Miniature Basic Switch** · **Industrial Limit Switches**



noise-free

response

on 90 low-level

PDM channels

...with CEC's **PLEXICODER**

Rocketdyne, a division of North American Aviation, Inc.

Noise problems and signal distortion, always solid obstacles to the use of sensitive *low-level* pickups for PDM, are *now eliminated* by CEC's PLEXICODER. Providing PDM conversion and commutation of the signals from flux and strain gages, resistance thermometers, thermocouples, and other low-level pickups, the PLEXICODER employs no troublesome filters, amplifiers or mechanical wiper arms. Operation is based on a noise-free galvanometer optical system with inherent filtering characteristics. The PLEXICODER is ideally suited for use with data handling systems, engine test stands, and missile ground-checkout equipment. Operating at speeds up to 900 samples per second, it easily accommodates 90 low- or high-level inputs in any combination.

The PLEXICODER utilizes simple oscillograph-proved techniques for adjustment and calibration. It is designed for a minimum of 1000 service-free hours of operation. Call your nearest CEC sales and service office for full information, or write for Bulletin CEC 1599-X14.

Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / *300 N. Sierra Madre Villa, Pasadena, Calif.*

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

CIRCLE 48 ON READER-SERVICE CARD

ure high dc currents—was introduced at the meeting. A Russian speaker said that by measuring the frequency change in the nucleus precession rate, he had obtained accuracies of better than 0.05 percent when working with dc currents above 500 amps.

• **From Czechoslovakia**—A method of gear-tooth checking, widely used in Czechoslovakia, registers on magnetic tape the passage of each tooth as it rotates. Time intervals between the pulses are analyzed for tooth-position errors, providing an accuracy better than 0.5 sec. of arc. The Czechs plan additional applications of this technique for dividing engines.

Reception to the measurements conference was good enough for the Hungarians to plan another one. The date: sometime in 1961.

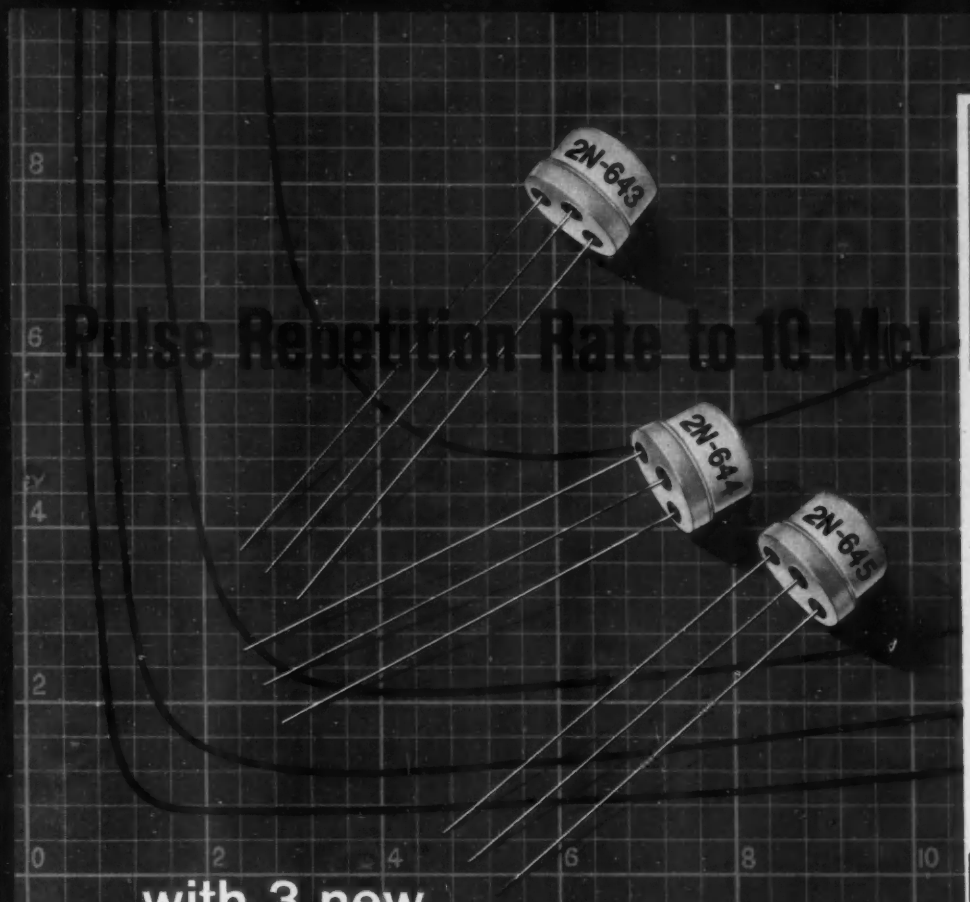
British Computer Merger

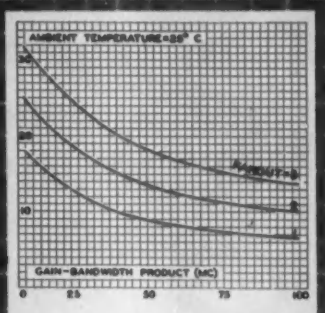
Recently announced merger of two major computer firms—British Tabulating Machine Co. and Power-Samas Accounting Machines—represents the first move by the British computer industry to gird itself for competition in the world markets.

Result of the merger is a new trading company, International Computers & Tabulators, Ltd. ICT is a jointly-owned operation: BTM owns 62 percent and Vickers, Ltd. (the parent company of Power-Samas), the remaining 38 percent. Assets of the new company are rated at $42 million; its staff totals 15,000. To finance the deal, BTM increased its capital from $15 million to $24 million. Of this, $10 million will go to Vickers in a swap for Power-Samas' share capital.

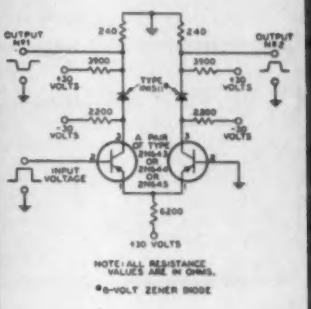
But problems remain before ICT becomes fully operational. The biggest is how to reduce the number of computer models offered by the new company. Both BTM and Power-Samas have a comprehensive line. From BTM comes the 555 plugboard programmed calculator, the 1200 high speed machine, and, due in 1961, the 1400 machine with a 16-microsec word-transfer time.

Comparable with the BTM 555 is the Power-Samas PCC plugboard computer (over 130 are on order). R&D collaboration with Ferranti resulted in the Pluto system, in which the Power-Samas punched-card system is adapted to a Ferranti Pegasus machine. Since both the 1400 series and Pluto were designed to fill the same role, ICT has a difficult choice deciding which will go into production.





Curves illustrate typical delay time per stage vs. gain-bandwidth product and fanout for the switching circuit shown below.



NOTE: ALL RESISTANCE VALUES ARE IN OHMS.

*6-VOLT ZENER DIODE

...with 3 new RCA DRIFT TRANSISTORS for COMPUTER APPLICATIONS!

TYPE	2N643	2N644	2N645
Minimum gain-bandwidth product* Mc	20	40	60
Minimum collector** breakdown volts	30	30	30
Minimum DC current transfer ratio*	20	20	20
Maximum collector capacitance μμf	5	5	5

*Collector Volts = -7, collector ma = -5
**Collector Current = 100 μa

RCA-2N643, RCA-2N644, and RCA-2N645 feature controlled minimum gain-bandwidth products, of 20, 40, and 60 Mc

RCA continues to pioneer superior-quality semiconductor devices with the new RCA-2N643, RCA-2N644, and RCA-2N645 "Drift" transistors. These three new units feature controlled minimum gain-bandwidth products permitting the design of extremely high-speed non-saturating switching circuits with rise, fall, and propagation time in the order of 20 millimicroseconds.

For your high-speed switching circuits requiring pulse repetition rates up to 10 Mc, investigate the superior design possibilities and benefits available to you with the new RCA "Drift" transistors—RCA-2N643, RCA-2N644, and RCA-2N645—hermetically sealed in cases utilizing dimensions of Jetec TO-9 outline. Your RCA field representative has complete details. Call him today. For technical data, write RCA Commercial Engineering, Section D-56-NN, Somerville, N. J.

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AVAILABLE, TOO, AT YOUR LOCAL AUTHORIZED RCA DISTRIBUTOR

ONE SOURCE FOR ALL YOUR CONDUCTIVITY CELLS



BODY MATERIAL

Choose from the widest range of body materials...polystyrene, lucite, epoxy, nylon, polyethylene, bakelite, hard-rubber, Teflon, Kel-F, stainless-steel, Monel, nickel and glass to meet every requirement for temperature, pressure and corrosion resistance.

PHYSICAL RANGE

Select the cell specifically designed to meet your application requirements... no need to settle for a universal compromise. Industrial Instruments manufactures conductivity cells for operation under pressures up to 7000 PSI.

CONDUCTIVITY RANGE

The most comprehensive line of cell ranges and constants available anywhere for every application from measurement of ultra-pure water to concentrated solutions of highly corrosive acids, alkalis and salts.

ELECTRODE MATERIALS

Nickel, platinum, graphite, gold or tin ...each one tailored to perform a specific job properly. Submit your particular requirements to us. Over twenty years' experience in the electrolytic conductivity field.

Write on your letterhead for our new Conductivity Catalog.

Industrial Instruments Inc.

89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 49 ON READER-SERVICE CARD

AROUND THE BUSINESS LOOP

Like a City Skyline

Graph control-company statements for fiscal 1958; and that's what you'd see; but embodied in all of these statements is a broad pattern of health.

Even with the dubious assistance of the recession, it was hard to divine a pattern in the latest annual statements of companies in the control field. That is, the recession might have been expected to act as a common leveler, but it did not; as the box on this page shows, business in 1958, in control engineering, at least, could be graphed to the jagged highs and lows of a city skyline.

In the third- and final-quarter figures of most of the statements, however, a pattern did begin to emerge—and it was a pattern of recovery from nearly all the ills that, by virtue of their seemingly disconnected nature, had given fiscal 1958 such a puzzling character. Moreover, judging from statements on the first quarter of the new fiscal year, this recovery is still putting on steam.

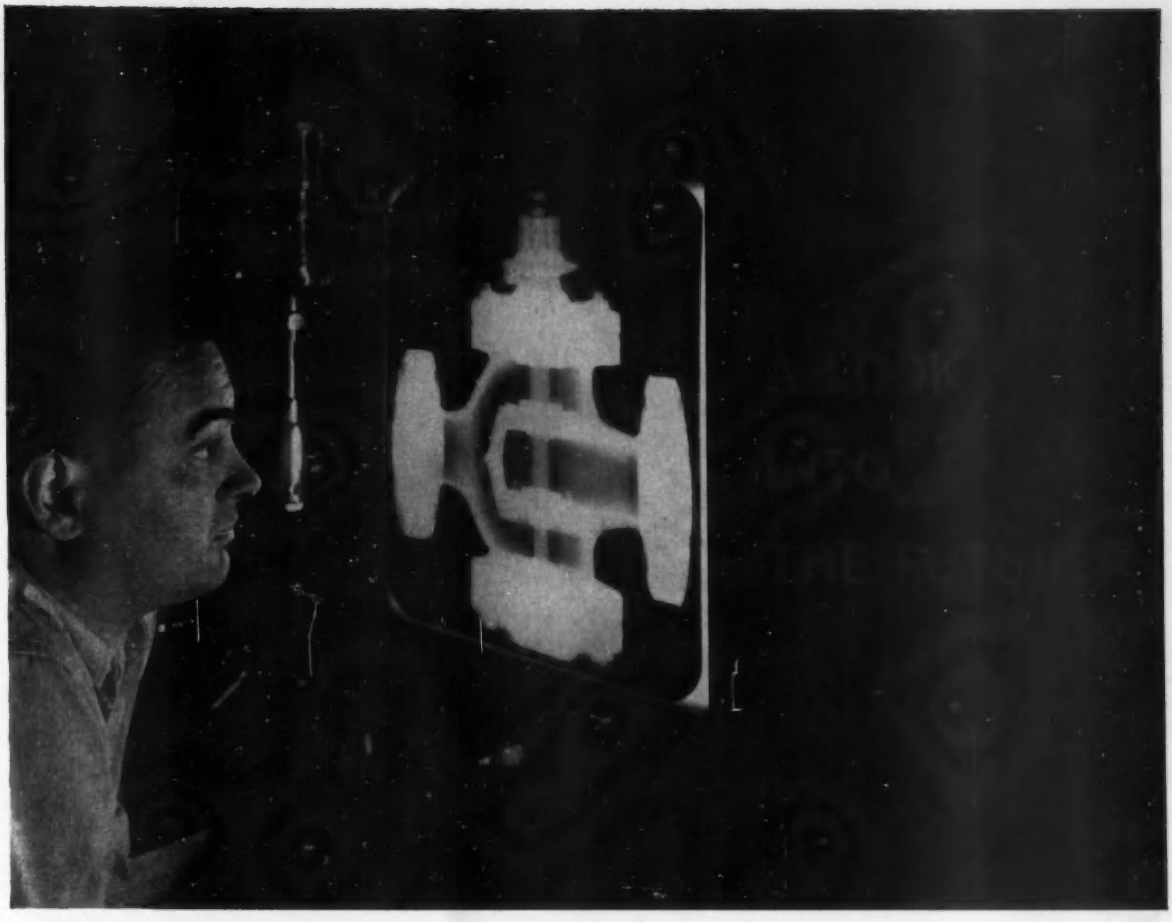
• **A spot-check**—Some of the annual statements in this issue previously appeared in the February issue (page 138). They are reproduced here, together with an approximately equal number of later statements, to emphasize the nature of this precocious business. The following spot-check examination of the table below just begins to show the profusion of reasons for the ups and downs in the commercial aspects of the field.

Baird-Atomic, Inc. — Came from way, way behind last year—it had an operating loss of $129,300 for the first six months, actually had to set up reserves during that period to meet the general business decline—to increase its net earnings by a fabulous

COMPANY STATEMENTS[1]

Company	$	%
American Bosch Arma[2]	4,785,723	(+21.5)
	115,877,176	(−13.7)
American Machine & Metals[2]	2,246,612	(−20.8)
	43,612,896	(−2.9)
Baird-Atomic[2]	125,900	(+577)
	6,744,800	(+1.5)
Beckman[2, 4]	39,823,317	(+4.0)
Burroughs[2]	6,407,934	(−36.4)
	294,085,078	(+4.0)
Clevite[2]	3,109,246	(−22.4)
	64,720,789	(−11.2)
Collins Radio[6]	1,936,197	(−12)
	107,569,000	(−16)
Consolidated Diesel Electric[6]	337,611	(+40)
	21,871,809	(−26)
CEC[5, 4]	32,079,000	(+5.03)
Consolidated Elec. Ind.[2]	1,452,814	(−26.3)
	27,518,655	(−3.9)
Control Data[2, 4]	625,756	first year
Dresser Industries[7]	9,882,000	(−47.0)
	225,264,000	(−18.0)
Eastern Industries[3]	954,058	(−20.8)
	11,766,494	(−14.6)
Electronic Associates[5]	315,000	(−68.6)
	10,216,000	(−16.9)
Electronic Communications[6]	568,309	(+132.6)
	21,191,882	(+25.1)
Fischer & Porter[6]	146,000	(−70.02)
	15,228,000	(+5.6)
General Controls[5]	1,438,933	(+21.1)
	33,774,321	(+12.8)
Hewlet-Packard[7]	2,212,497	(−7.8)
	30,296,647	(+8.4)
IBM[5]	126,191,858	(+41.2)
	1,171,788,199[9]	(+17.1)
International Resistance[5]	504,268	(+7.4)
	13,743,865	(−10.6)
Litton Industries[6]	3,700,000	(+105.0)
	83,000,000	(+196.0)
W. L. Maxson[2]	53,170	(−76.0)
	15,185,233	(−23.0)
Nuclear-Chicago[10]	442,252	(+74.0)
	3,851,078	(+45.0)
Packard-Bell[2]	1,002,593	(+42.0)
	37,371,081	(+16.0)
Raytheon[5]	9,403,000	(+94.7)
	375,156,000	(+44.3)
Reliance E&E[7]	3,772,748	(−38.0)
	70,591,510	(−26.0)
Robertshaw-Fulton[5]	4,008,819	(+2.3)
	68,771,939	(−4.3)
Sanders Associates[6]	233,487	(−7.03)
	8,969,770	(+60.08)
Siegler[8]	1,125,930	(+16.0)
	72,955,449	(+125)[11]
Statham[14]	527,784	(+14.0)
	5,088,659	(+13.0)
Telecomputing[7]	343,677	(−11.7)
	29,490,049	(+10.9)
Texas Instruments[5]	6,001,000	(+59.6)
	91,954,000	(+36.5)
Thompson—R-W[5]	8,979,232[12]	(−26.0)
	340,621,767[12]	(−17.4)
Westinghouse[5]	74,772,000	(+2.9)
	1,895,699,000[13]	(−5.6)
Universal Winding[8]	68,594	(−83.0)
	14,316,622	(−4.8)

[1] First figure is net earnings, second is net sales; percentages reflect increases or decreases with respect to preceding fiscal year. [2] Fiscal year ending Sept. 30, 1958. [3] Fiscal year ending June 30, 1958. [4] Net earnings negative; only net sales shown. [5] Fiscal year ending Dec. 31, 1958. [6] Fiscal year ending July 31, 1958. [7] Fiscal year ending Oct. 31, 1958. [8] Fiscal year ending April 31, 1959. [9] Includes gross income from sales, service, and rentals. [10] Fiscal year ending Aug. 31, 1958. [11] Includes operations of two 1958 acquisitions. [12] As reconstructed on a combined basis. [13] Includes products and services. [14] Fiscal year ending May 31, 1958.



Neither stargazer nor mystic, this K & M technician can nevertheless see into the future. His crystal ball is a small mass of radioactive Iridium; his fortune-telling cards, gamma-ray pictures of critical valve assemblies. With these pictures he searches out the kind of subtle flaws and tiny imperfections that could become trouble spots at some future time. And so he is able to predict and prevent in-service failures and malfunctions.

Radiographic inspection is just one way in which K & M works to insure a long and healthy service life for its products. K & M's in-plant quality control facilities range from a contour comparator, for precision checking of small parts, to a 4000-gpm flow test loop, where sample valves from the production line are tested for on-stream performance. Micrometer and calipers play an important part, too, for each K & M valve is subjected to more than eight hundred dimension check-outs before it reaches the shipping crate. It's either perfect, or "no go."

K & M's meticulous standards of quality control are neither myth nor magic . . . just good business — for us, and for you.

For a more detailed view of our plant and production practices, send for the well-illustrated, informative brochure, "This Is K & M."





K&M

diaphragm control valves

Our 79th Year

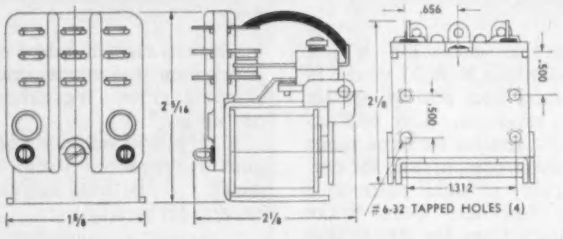
KIELEY & MUELLER, INCORPORATED

Oldest Pressure and Level Control Valve Manufacturer
64 Genung Street, Middletown, New York

CIRCLE 50 ON READER-SERVICE CARD



power relay



New, rugged power relay assures long-life and trouble-free operation at lowest cost. Single coil construction employs box-type magnetic field. Movable contact springs, mounted on molded phenolic insulating bars provide positive contact alignment. ¼" diameter contacts available in silver or silver cadmium oxide, rated singly at 10 to 25 amperes, 110 volts A.C., non-inductive. Available contact forms 1C to 5C. Construction permits maximum contact pressures 35 grams each. D.C. relays incorporate use of high quality iron annealed for maximum efficiency. A.C. relays have silicon iron parts with copper shading washers. Coil and contact terminals are located at one end. Write for complete details.

Write for new free Comar catalog

COMAR

ELECTRIC COMPANY

3349 ADDISON ST., CHICAGO 18, ILL.

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

CIRCLE 51 ON READER-SERVICE CARD

WHAT'S NEW

577 percent (from $18,600 to $125,900). These reserves, taken back into earnings, helped to account for the improvement. So did increased sales in the third and fourth quarters.

Beckman Instruments, Inc., Consolidated Electrodynamics Corp., and *Control Data Corp.*—All reported substantial net income losses for the year: Beckman's amounted to $946,923, CEC's to $1,178,496, and Control Data's to $114,716. Beckman and CEC cited similar reasons: nonrecurring losses, heavy investments in research, and high production costs. Control Data cited heavy getting-started costs.

All three began to recoup their losses before the year was out. On Sept. 30, 1958, Beckman's net income for the first three months of its fiscal year was ahead of 1957 by about 113 percent ($619,843, as compared to $290,712). This was equal to 22 cents a share on the common stock outstanding, in contrast to a 70-cent loss on every share, on the common outstanding, at the end of the fiscal year in June.

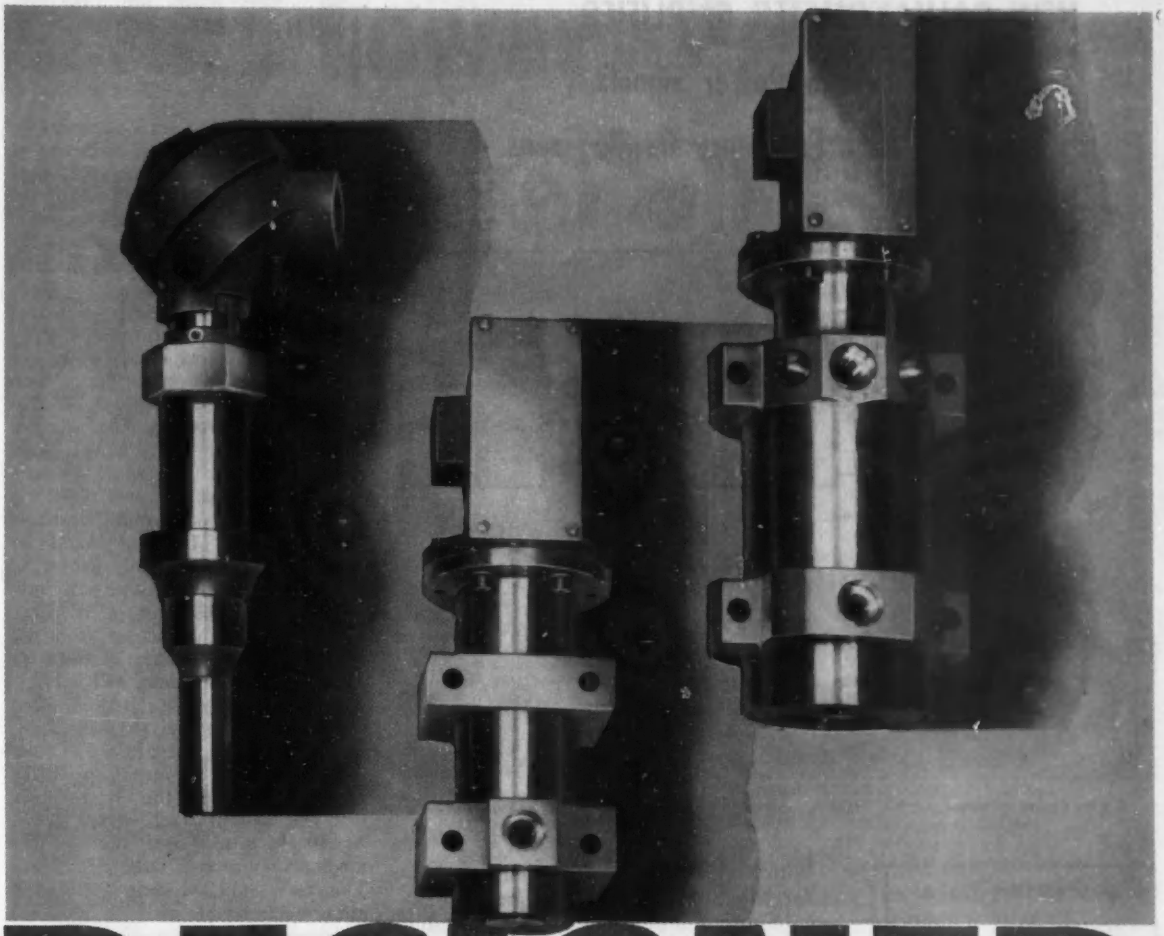
• **Reverses under control**—For CEC, too, the worst was over nine months after 1958 got under way. Said President Philip S. Fogg, "Predictions for 1959 are difficult at this time. We believe, however, that most of the major influences which have adversely affected the company's profits during the past 18 months have been corrected." For substantiation, Fogg pointed to the development of a number of new product areas, the result of a four-year program of intensive R&D work.

As for Control Data, it could report a net profit of $31,697 on net sales of $1,466,433 for the first half of its new fiscal year, which begun June 30, 1958. In addition, backlog was up $1 million, from $2 to $3 million, and progress on an all-transistor digital computer had accelerated to the point where CD was confident of making its first delivery this summer.

Finally the first two companies could report record-high sales and new orders to somewhat offset the effect of their income losses.

Fischer & Porter Co.—Also partly blamed the recession for its ills, principally a 70-percent decline in net income, but then explored a problem indigenous to itself: under-pricing and under-manning. About the "unhappy situation" in the Data Reduction Div., President Kermit Fischer had this to say:

"Needless to say, our experience



DESIGNED

SPECIFICALLY FOR NUCLEAR APPLICATIONS

These transducers are an engineered family of highly reliable instruments for measuring pressure temperature, flow, liquid level and differential pressure. » » Compact and rugged construction enables the units to meet the severe environmental conditions of MIL-N-19900 while maintaining outstanding accuracy. » » For any transducing application wherein reliability is a paramount consideration you should review the specification of these nuclear transducers. ***Consolidated Controls Corp.*** also designs and manufactures complete Instrumentation and Control Systems using static components. Complete details available by contacting Dept. NT.

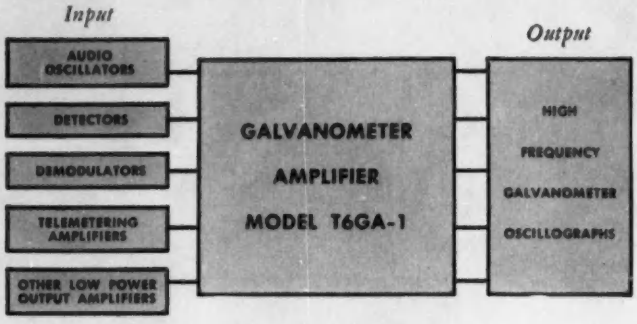
CONSOLIDATED CONTROLS CORP.

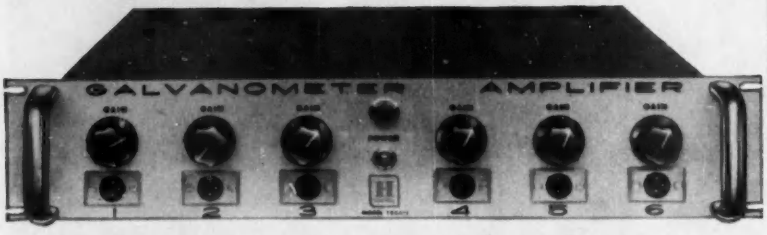
BETHEL, CONN., INGLEWOOD, CALIF.
A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION,
STAMFORD, CONNECTICUT

CIRCLE 52 ON READER-SERVICE CARD

NEW GALVANOMETER AMPLIFIER

Strengthens Low Power Signals to Drive High Frequency Oscillographs





Galvanometer Amplifier, Model T6GA-1, measures 3½" high, 19" wide, 15½" deep.

DESCRIPTIVE DATA

VOLTAGE GAIN: Adjustable from 0 to 1.0

OUTPUT (37 OHM LOAD): ±2.4 volts at 65 ma d-c to 8 Kc, limits at ±100 ma.

OUTPUT IMPEDANCE: 2 Ohms d-c to 10 Kc

CONTROLS: 6 GAIN controls, 1 Power ON-OFF switch

INPUT IMPEDANCE: 47 K

ISOLATION: Individually floating channels for use with ungrounded loads

NOISE: Less than 3 mv peak-to-peak

DRIFT: Less than 3 mv/°F

POWER REQUIREMENTS: 115 volts ±10 volts, 50 to 440 cps, 45 watts

With Honeywell's new Galvanometer Amplifier, Model T6GA-1, high frequency oscillographs can now be operated directly by low power input sources of 1 volt or more. These inputs, some of which are shown in the diagram above, should have output impedances of 10 K or less although higher source impedances can be tolerated. Noise and drift are indistinguishable on the recorded output when the galvanometer-amplifier combination has a maximum sensitivity of 1 inch per volt.

The Model T6GA-1 is a compact, six channel, three stage transistor d-c amplifier with overload protection to eliminate both danger of transistor damage and galvanometer burnout.

Each of the six amplifier channels is isolated from ground by individual floating power supplies. Write for Bulletin B-ET6 to Minneapolis-Honeywell, Boston Division, Dept. 34, 40 Life Street, Boston, Mass.

Honeywell

H HONEYWELL *First in Control*

CIRCLE 53 ON READER-SERVICE CARD

WHAT'S NEW

over these past two years precludes the possibility of a repetition of these conditions on any new commitments. However, till we have digested the last of the under-priced, under-engineered Data Reduction System orders, the fine work being accomplished throughout our company will not be fully recognizable in our balance sheet."

Packard-Bell Electronics Corp—Continued—almost defiantly—to occupy the plus side of the ledger as it approached 1959. Sales for the first quarter of its fiscal year (September to December of 1958) increased 50 percent to a new high, while net earnings soared 93 percent over those registered for the same period a year ago.

International Business Machines Corp.—The nonrecurring nature of this company's net income was indicated in a previous story (CtE, Dec. '58, p. 120). This income, from the outright sale to customers of machines formerly leased to them, will not "recur" as rent on future statements, and so cannot be applied to these statements. In 1958, there was $15,636,122 in nonrecurring income in IBM's net figure; in 1957, the first full year that the consent-to-sell decree (CtE, March '56, p. 30) was in force, this income amounted to only $3,927,000. Therefore, said IBM, earnings for 1958 are not comparable with 1957, do not represent an accelerated growth rate.

International Resistance Co. — Came from behind (it had a net loss in the first half of 1958, of $71,248) to exceed 1957's net profit by 7.4 percent. President Charles Weyl told how it did it: "International Resistance Co.'s management took prompt action to offset the effects of the recession. Expenses were drastically reduced, steps were taken to curtail activity in product lines which were becoming marginal, and some operations were consolidated to secure increased efficiencies."

Reliance Electric & Engineering Co. — Net earnings dropped by nearly one-half in 1958, and sales went down substantially, too. But it's possible that a deliberate retrenchment was at the bottom of the slide, for Reliance ended the year in a strong position.

• **Pulling in its lines?**—Moreover, a retrenchment would explain Reliance's curtailing manufacture of canned pump-motors for the atomic power program. In his note to stockholders, President Edward E. Helm blamed the curtailment on the magnitude of the risks involved, said that experience gained in the nuclear power field

CLARE Lowers Prices



Type HG



Type HGP



Type HGS



Type HG2



Type HG4

on all Mercury-wetted contact relays

Reductions range from 7½% to 10%

When prices for just about everything are continuing to rise, and all thinking men are concerned over the danger of inflation, it is important news when a manufacturer makes a significant price reduction.

Increased production resulting from the wide acceptance of Clare Mercury-Wetted Contact Relays, together with improvements in skill and in manufacturing equipment and methods, make it possible for Clare to reduce prices for these superior relays in spite of rising labor and material costs.

A price reduction ranging from 7½% to 10% will be applied to all orders placed after March 31, 1959, for Clare Mercury-Wetted Contact Relays—Types HG, HGP and HGS. The reduction will also affect multi-element relays such as HG2, HG3, HG4, etc.

These lower prices for relays whose life is measured in *billions of maintenance-free operations* will be exciting news to all designers of continuous-duty, high-speed switching devices and systems.

Write or Wire: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

CIRCLE 54 ON READER-SERVICE CARD

imc

SERVO MOTOR-GENERATORS FOR INSTANT ERROR-SIGNAL RESPONSE



A significant result of Induction Motors' creative engineering program in recent years is the growing series of precision servo motor-generators . . . Sizes 8, 11, 18 (shown above) plus sizes 10, 15, and 20.

These units constructed to meet the latest applicable MIL specifications covering extreme environmental conditions incorporate the design objectives of light weight, high performance, and reliability at reasonable cost.

The high torque-to-inertia characteristic of these servo motor-generators offers high acceleration and immediate accurate response to error signals.

GENERATOR CHARACTERISTICS
Input: 18V 400 cps, 1.65 watts
Voltage gradient per 1000 RPM: 0.27V
Temperature range: —55°C. to +150°C.
Null Voltage (max): 0.015V rms
Phase shift: within 10° of Reference

SIZE 8
O.D. = 0.750
L = 2-1/32
J = 0.75 gm cm²
Wt. = 2.86 oz.

MOTOR CHARACTERISTICS
Input: 18V 400 cps 4.7 watts per phase
Torque at Stall: 0.42 oz. in.
No Load Speed: 6200 rpm
Power Factor: 0.875
Theoretical Acceleration at Stall: 39000 rad/sec²

Design characteristics of IMC's Size 8 to Size 20 series of servo motors and servo motor-generators, as well as full technical data on IMC DC motors and dynamotors; axial, vaneaxial, and centrifugal blowers; hysteresis and torque motors; synchros and solenoids, can be obtained by writing on company letterhead to IMC's Sales Engineering Dept. All IMC components can be designed to your particular requirements with the same precision and accuracy.

Induction Motors Corp.

570 MAIN STREET/WESTBURY, L.I., N.Y./EDGEWOOD 4-7070 • 6058 WALKER AVE./MAYWOOD/CALIF.

CIRCLE 55 ON READER-SERVICE CARD

would help Reliance to reestablish the line in the future, if it wanted to do so.

Sanders Associates, Inc.—Sales were the big thing with this New Hampshire company in 1958. The table shows only that overall sales rose by 60 percent; but Sanders was equally proud of the fact that more manufactured products went out than ever before. The 123 percent increase for these products swept them beyond engineering sales for the first time in the company's history. For the future, Sanders sees a particularly healthy market for flexible printed wiring.

The Siegler Corp.—For Siegler, the story, at least during fiscal 1958, was also sales: its 125 percent increase in this area reflected a jump from $32,719,078 to $72,955,449. But with the start of the new fiscal year in June 1958, the plot turned to earnings. On Dec. 31, 1958, with half of the new fiscal year still to go, these earnings were already greater than those for the entire fiscal year just passed. The net on this date was $1,231,661, compared to $1,215,930 for fiscal 1958. Sales were also up slightly over the first half of that year.

Universal Winding Co.—Could say, on June 30, 1958, that it was fortunate to end its fiscal year in the black. Main reason: the textile industry, buyer of most of UW's winding machines, was in a depressed state. But with the new fiscal year, net income, just for the first half alone—to Dec. 31, 1958—soared to $313,943, production started to increase on the Unifil Loom Winder, and sales of electrical coil winders rose 25 percent. In addition, the pace of electronic research picked up considerably.

Topp Industries Has Eye on Phoenix Semiconductor Firm

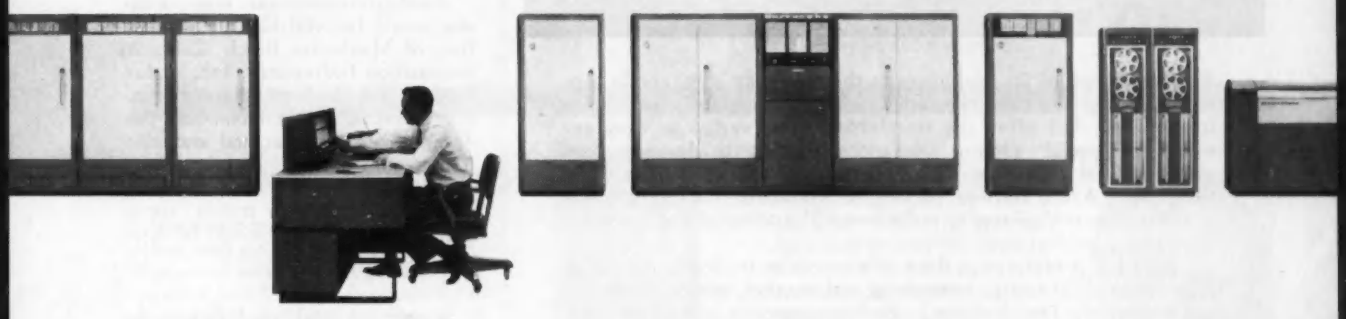
Topp Industries, Inc., announced almost simultaneously in February that it was planning to acquire U. S. Semiconductor Products, Inc., of Phoenix, Ariz., and that it had formed a new corporation, U. S. Science Corp., to take over its own Topp Mfg. division. USC will consolidate the division's aviation programs, receiving all aviation business—communications, navigation, and components—on a subcontract basis from Topp Industries, and will seek to increase its predecessor's operating efficiency.

Topp Industries has done well for itself in the control-company market, making several significant acquisitions in less than two years. For fiscal 1958,





proven again and again: Burroughs 205 Computer



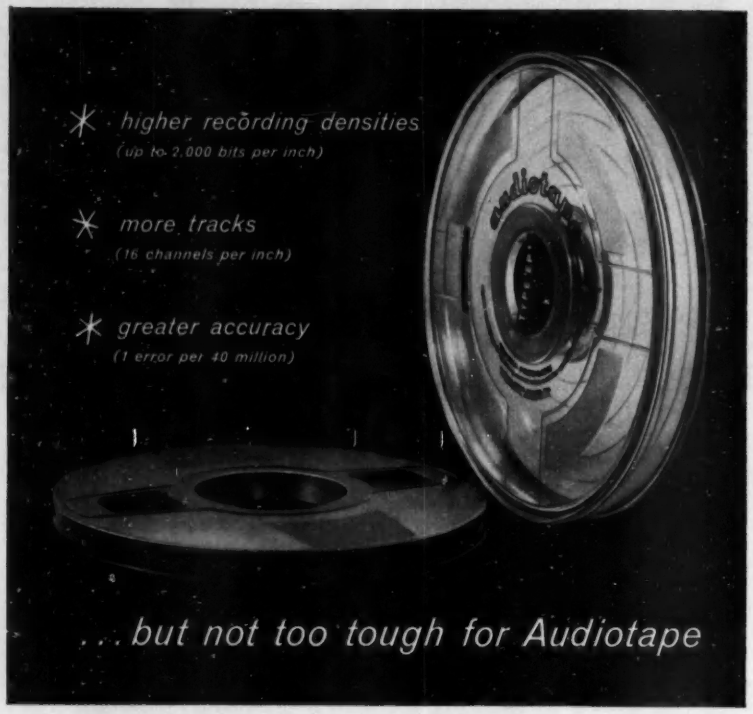
Designed to handle with ease a wide range of computational problems, the Burroughs 205 is delivering results daily in a great variety of scientific and business applications... from refinery design to inventory control, wind tunnel test analysis to insurance premium billing, telemetered data reduction to operations research. The 205 was selected to work on these and countless other tasks because of its speed, 4080 words of memory, ease of program loading, vast magnetic tape storage capacity and multiple-card processing versatility... features which make the 205 today's best dollar-for-dollar computer value. The 205 is just one part of a complete line of Burroughs electronic data processing equipment, helping hundreds of industrial users to save precious man-hours and to solve important problems. Write for 205 brochure, ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

CIRCLE 56 ON READER-SERVICE CARD

Tape specs are getting tougher every year



Keeping *ahead* of its customers is the only way a magnetic tape manufacturer can meet the rapidly rising standards being set for its product. And often the standards are as varied as they are exacting. Special slitting tolerances, coating thicknesses, base materials and magnetic oxides are rapidly becoming more usual than novel. Audio Devices' battery of Automatic Certifiers is one of the unique means used to make sure EP Audiotape always meets customer specifications.

Type EP Audiotape is the *extra precision* magnetic recording tape for applications in computing, automation, telemetering and seismography. The Automatic Certifier records and plays back every inch of the EP Audiotape under test. These tests can be so demanding that if the tape fails to reproduce a single test pulse out of the 40 million put on a single reel, the entire reel is rejected. There are no ifs, ands or buts.

This is one of many special quality-control operations to which EP Audiotape is subjected. From raw materials to hermetically sealed containers, every reel gets individual attention.

EP Audiotape quality is so well verified by instruments like the Automatic Certifier that every reel is guaranteed to be defect-free! For more information write for free Bulletin T112A. Write Dept. TC, Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

TYPE **EP audiotape** TRADE MARK

AUDIO DEVICES, INC.
444 Madison Ave., N. Y. 22, N. Y.
In Hollywood: 840 N. Fairfax Ave.
In Chicago: 5428 Milwaukee Ave.
Export Dept.: 13 East 40th St., N. Y., 16
Rectifier Division: 620 E. Dyer Rd., Santa Ana, Calif.

CIRCLE 57 ON READER-SERVICE CARD

it projected net profits of 85 cents per share (they were somewhat more than 60 cents per share in 1957) on sales of $14 million ($9 million previously).

At the end of 1958, Topp could announce that orders totaling more than $100,000 had been received for its new Micro-Path control system (CtE, Jan., p. 28), a machine-tool control that combines the numerical control concepts of point-to-point positioning and contouring, and effects responses accurate to 0.002 in. Purchasers included Hughes Aircraft, Republic Aviation, Cummins-Chicago, and Ryan Aeronautical.

Physical assets of U. S. Semiconductor Products have been put at $1.2 million. The firm is now in full production on 10 semiconductor devices, expects to add 10 more to its line within the next year. Sample: a hyperpure monocrystalline silicon disc lens for missile homing devices. The next full fiscal year, says Topp, should see USSP's sales rise to $3.5 million.

Automation Instruments, Inc., Mid Continent Weigh Tie

Another negotiation now under way would tie Mid Continent Mfg., Inc., of Manhattan Beach, Calif., to Automation Instruments, Inc., of Los Angeles, also by acquisition. The result would be a $3-million-a-year producer of aircraft structural and electronic components, electronic systems and subsystems, and ultrasonic and other nondestructive testing apparatus. Mid Continent would be operated as a subsidiary.

* * *

Already an established fact is the acquisition of the entire RCA relay line, by North Electric Co. of Galion, Ohio. This new business, together with some new relays just released by North's own laboratory, should add several millions of dollars in sales to North's books in 1959.

Now It's

Michigan Special Machine Co. of Warren, Mich., formerly Michigan Drill Head Co. Activities involve transfer, rotary, trunion, and other special machines.

Inso Electronic Products, Inc., of Union, N.J., formerly Inso Products, Ltd. The firm produces fused-film Teflon insulated wire and cable.

The **Denver Laboratories** of the

BURROUGHS COMPUTER SYSTEM COMPONENTS

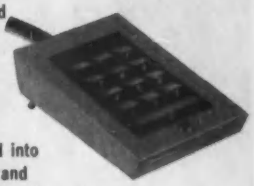
MANUAL TAPE PUNCH

Eliminates the problem of re-inserting perforated tape for repunching in the main perforating unit. A precision unit with particular application as a method for insertion of information into an already prepared tape. It accommodates standard Teletype and Commercial Controls Flexowriter tapes, and corrects up to an 8-hole code. Tape is easily inserted through a guided slot and held in perfect register.



DECIMAL KEYBOARDS

The answer to the widespread need for a modestly priced, versatile manual-input device. Thoroughly proven with the Burroughs 205 and 220 computing systems, the Decimal Keyboard is a 13-key unit that can be readily integrated into a wide variety of data processing and communications systems. Compact, with feather-light touch which provides high speed of input. A 16-key unit is also available.



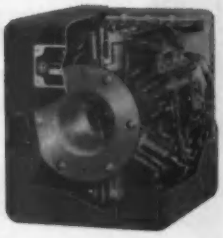
PINBOARD PROGRAMMING ASSEMBLIES

Used in the Burroughs E101 desk-size computer, now individually available as a basic control unit or stored program device. Simple and versatile: a single pin completes a circuit. Complete programs can be quickly changed by inserting previously prepared plug-in units. Expandable, with three types of pinboard receptacle units. Compact: 11¾" by 3⅜".



MAGNETIC STORAGE DRUM

A small, high-speed magnetic drum for intermediate storage—proven in use with Burroughs 205 and 220 computing systems. It buffers information between the computer and various input-output units. Revolves at 21, 600 rpm, permitting access to stored data in average time of 1.4 milliseconds. Easy matching with either transistor or vacuum tube circuitry. Furnished complete, including 10 dual read-write head assemblies and drive motor.



DIGITAL MAGNETIC TAPE TRANSPORTS

Several transports are offered to meet a variety of tape speed and tape width requirements. Bi-directional units operate at speeds up to 75 inches per second. Multiple speed units are also available. Ten-speed transport handles tape at speeds from 1½ to 90 inches per second. All transports incorporate vacuum controlled reel servo systems for gentle tape handling, end-of-tape sensing, fast start and stop, remote and local control, easy threading and dust free operation. A file protection device and air-conditioning manifolds are available. Years of proven reliability in Burroughs computer systems and other digital applications.



PHOTOREADER

Reads 1,000 characters per second... stops on a single character, then reads the next within five milliseconds after restart. The finest and fastest precision perforated paper-tape-reader commercially available as a component. Developed as an input unit for the Burroughs 220 computing system, the Photoreader may be mounted in any standard 19" cabinetry—or ordered already housed in the 220 cabinet, as pictured.

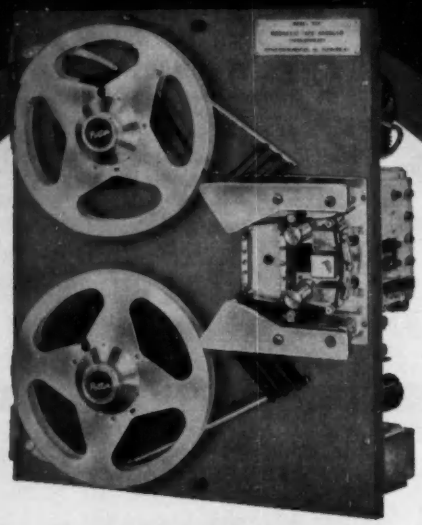


For complete details on these or other Burroughs Computer System Components, write to Component Sales, ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

New Speed...Versatility...Reliability...



TRANSISTORIZED DIGITAL MAGNETIC TAPE HANDLER MODEL 906

• Check these new standards of reliability and performance

- Completely transistorized for maximum reliability
- Trouble free brushless motors
- Over 50,000 passes of tape without signal degradation
- Linear servo system
- Life expectancy of pinchroll mechanism: over 100,000,000 operations
- Skew ± 3 μsec ½" tape, center clock at 100 i.p.s.
- Vacuum loop buffer
- Continuous flutter free cycling 0 to 200 cps
- Normal speed up to 100 i.p.s.
- Rewind or search speed constant at 300 i.p.s.
- Six speeds forward or reverse up to 150 i.p.s.
- Better than 3 milliseconds start, 1.5 millisec. stop
- Front panel accessibility
- In line threading
- End of tape and tape break sensing
- All functions remotely controllable
- Tape widths to 1¼"

The 906 is usually supplied with the Potter 921 transistorized Record-Playback Amplifier; a unit that features:

Pulse or level outputs
Output gating
1 i.p.s. to 150 i.p.s.
Manual, relay, or electronic function switching
Dual read-write operation

Potter also manufactures a complete line of Perforated Tape Readers, High Speed Printers and Record-Playback Heads.

Contact your Potter representative or call or write direct for further information.

Potter
The mark of Engineering Quality

POTTER INSTRUMENT COMPANY, INC.
Sunnyside Boulevard, Plainview, N. Y.
OVerbrook 1-3200

Potter has career opportunities for qualified engineers who like a challenge, and the freedom to meet it.

CIRCLE 59 ON READER-SERVICE CARD

WHAT'S NEW

Ramo-Wooldridge Div. of Thompson Ramo Wooldridge Inc., formerly R-W's Electronic Instrumentation Co.

FIER Focuses on ChemE Faculties

Last summer, the Foundation for Instrumentation Education & Research exposed 25 teachers of post-highschool technical colleges to the rigors of dynamic analysis (CtE, April '58, p. 40, and October '58, p. 48). The three-week course was as rewarding as FIER could have hoped. This coming summer it wants to repeat the performance, but with professors of chemical engineering in the learning roles. A $20,000 grant from the National Science Foundation to Case Institute, where the first conference was also held, says this one will be just as successful.

Co-sponsor with FIER this year is the Process Control Subcommittee of AIChE. Directing the three weeks (July 6-24) of intensive study will be Case's Prof. Donald P. Eckman and Prof. Irving Lefkowitz; both are known internationally for their work in process control. On the curriculum are lectures, laboratory experiments, and discussion periods, all aimed at development of control theory and at the mathematical background for dynamic analysis, as it applies to petroleum and chemical processes.

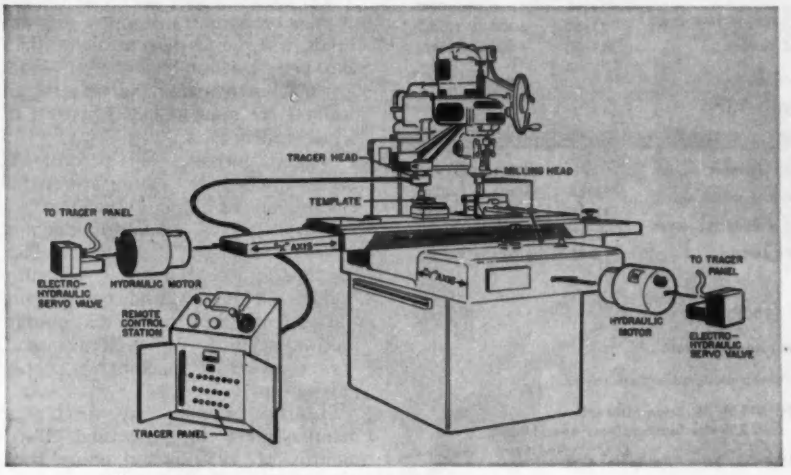
• **Too much stress on statics** – FIER argues that the teaching of chemical engineering in colleges is limited by its being mainly based on process statics. It is important, says FIER, that classrooms understand how industrial processes are continuously disturbed and continuously manipulated, and corrected against these disturbances by manual or automatic action—and thus how to define the dynamic response of processes quantitatively, by mathematics and servo techniques.

The foundation reported on an AIChE survey made in 1957, which found that of 107 college chemical engineering departments, only 52 had a process control or process instrumentation course in their undergraduate curricula; and that of the 52, only 32 had a preliminary course in ordinary differential equations. In effect, less than one-third of the schools surveyed were actually offering study in this important new area.

The FIER-AIChE conference will be limited to an enrollment of 30. Candidates can come from any AIChE-accredited college or university

for modern, efficient
machine control . . .

Honeywell's new Electro-Hydraulic Servo Systems and Components



360° electro hydraulic tracer control system

Tracer control systems—fast, accurate and reliable system response for smooth application of large increments of hydraulic power. The flexibility, remote control and intelligence of electronics are coupled with the power and "tight" actuation of hydraulics.

Speed control systems—speed ranges of 1000 to 1, speed regulation to 0.1%, and consistent speeds to 1 rpm are possible with electro-hydraulic speed control.

Position control systems—positioning of cylinders or motors to the most exacting specifications.

Speed and position—synchronization and programming—control of tension, force, level, torque, etc.

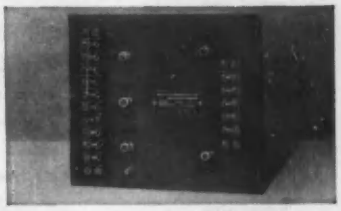
For further information on Honeywell's new machine control systems and components, and their application to your specific job, call your nearest Honeywell office. Or write: Minneapolis-Honeywell, Department CE-4-12, Minneapolis 8, Minnesota.

Honeywell

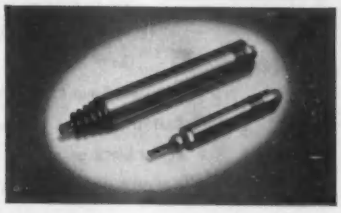
H HONEYWELL *First in Control*



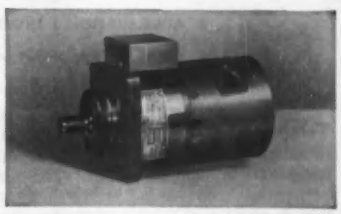
Electro-hydraulic servo valves—2-, 3- and 4-way valves with output flow proportional to input signal. Designed specifically for industrial use.



Transistorized servo amplifiers—proportional and integrating low voltage amplifiers designed for servo systems, incorporating servo valves, d-c relay and servo motors.



Feedback transducers—industrialized linear and rotary transducers providing accurate sensing and feedback for servo loops.



Hydraulic motors—roll-vane motors producing high torques at low speeds. Often connected directly to load. Integral tachometer optional.



Servo accessories—input commands, meters, manifolds, phase conversion panels, consoles, etc., to complement the servo control systems.

easily installed

factory calibrated

TRANS-SONICS

REG. T.M.

SURFACE TEMPERATURE TRANSDUCERS

actual size

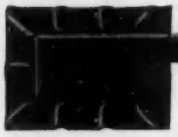


CEMENT-ON*, Type 1375

The temperature sensing element is encased by a die-formed wire screen which can be installed on any surface with TRANS-SONICS Type 64C cement.

TYPE	TEMPERATURE RANGE
1375A	−300 to +650F.
1375B	0 to 1000F.
1375C	+200 to 1250F.
1375D	+500 to 1550F.

actual size



WELD-ON*, Type 1376

The temperature sensing element is encased in a thin die-formed metal cover, and is installed by spot welding the cover to the underlying metallic surface.

TYPE	TEMPERATURE RANGE
1376A	−300 to +650F.
1376B	0 to 1000F.
1376C	+200 to 1250F.
1376D	+500 to 1550F.

- RANGES: From −400F to +1550F.
- OUTPUT: Up to 5 volts without amplification.
- RESISTANCE CHANGE: 100 ohms over calibrated range.
- ACCURACY OF CALIBRATION: ±1% of range interval
  ±2% for temperatures over 1000F.
- MAXIMUM CONTINUOUS CURRENT: 20 milliamperes rms.
- REPEATABILITY: ±0.2% of range interval.
- VIBRATION: 1-inch double amplitude, 0-22 cps;
  25g, 22-2000 cps.
- ACCELERATION & SHOCK: 100g on all three major axes.
- LEADS: Two 6" nickel wires with high temperature insulation.

Trans-Sonics Cement-On Type 1375 and Weld-On Type 1376 Surface Temperature Transducers are platinum resistance thermometers that can be installed on any surface, flat or curved, metallic or non-metallic, for accurate temperature measurement. The protective cover of the resistive element is cemented or welded directly to the thermal surface to form an isothermal system which gives a transducer reading that corresponds to the true skin temperature.

A 5 point resistance-temperature calibration certificate at 0, ¼, ½, ¾ and full scale temperature is supplied with each transducer. A strip of aluminum Thermotape* is also furnished with each unit to provide an alternate means of tape-on installation useful to 800F and under limited conditions to 1000F.

Types 1375 and 1376 are the newest members of the Trans-Sonics family of platinum resistance thermometers for measuring surface temperatures. All units are capable of delivering up to 5 volts without amplification. Write to Trans-Sonics, Inc., Dept. 11, Burlington, Mass. for Technical Bulletin on Surface Temperature Transducers.

*TRADEMARK

TRANS-SONICS

Precision Transducers

CIRCLE 61 ON READER-SERVICE CARD

WHAT'S NEW

now giving undergraduate instruction in chemical engineering. Besides free tuition, successful applicants will receive travel allowances and expenses of up to $15 per day (last year it was $6 per day). Write Foundation for Instrumentation Education & Research, 335 East 45th Street, New York 17, New York, for applications.

Machinery Orders on Way to Record, Says McGraw-Hill

The latest McGraw-Hill forecast of new orders for machinery (Feb. 10, 1959) indicates that the dollar volume of these new orders will top all previous totals, will rise 21 percent higher than the new business booked in 1958. The machinery manufacturers surveyed account for more than 40 percent of all machinery sales.

Biggest increase (49 percent) is being forecast by manufacturers of engines and turbines. Other increases are expected by metalworking machinery makers (39 percent), office machinery companies (29 percent), builders of pumps and compressors (20 percent), construction and mining machinery firms (13 percent), and "other industrial machinery" people (15 percent).

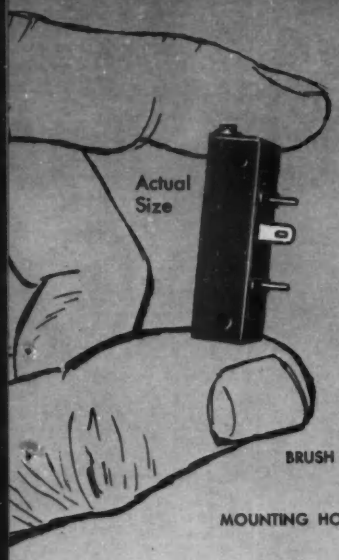
Healthy estimates by machinery manufacturers for the first three months of 1959 are standing firm despite lower-than-expected new orders for the last quarter of 1958, principally because expectations are tied to modernization plans.

• **Value Line in agreement**—Corroborating the results of the McGraw-Hill survey is the Feb. 23 report of the Value Line Investment Survey, published by Arnold Bernhard & Co., Inc., New York. This report points to a "fairly substantial rise in demand for machinery, which should carry this industry's shipments back to an all-time high in 1959". The prospects, the investment study hastens to add, are not for a boom; rather, they are for a gradual advance in orders and shipments, a slow but persistent growth that can add stability to the pricing structure of the "highly cyclical" machinery industry.

Machine tools and electrical equipment, says the Bernhard survey, are also showing signs of emerging from their slump. Incoming orders for the former rose sharply in December, continued to rise in January. So far, however, the principal beneficiaries of the change in the air are makers of

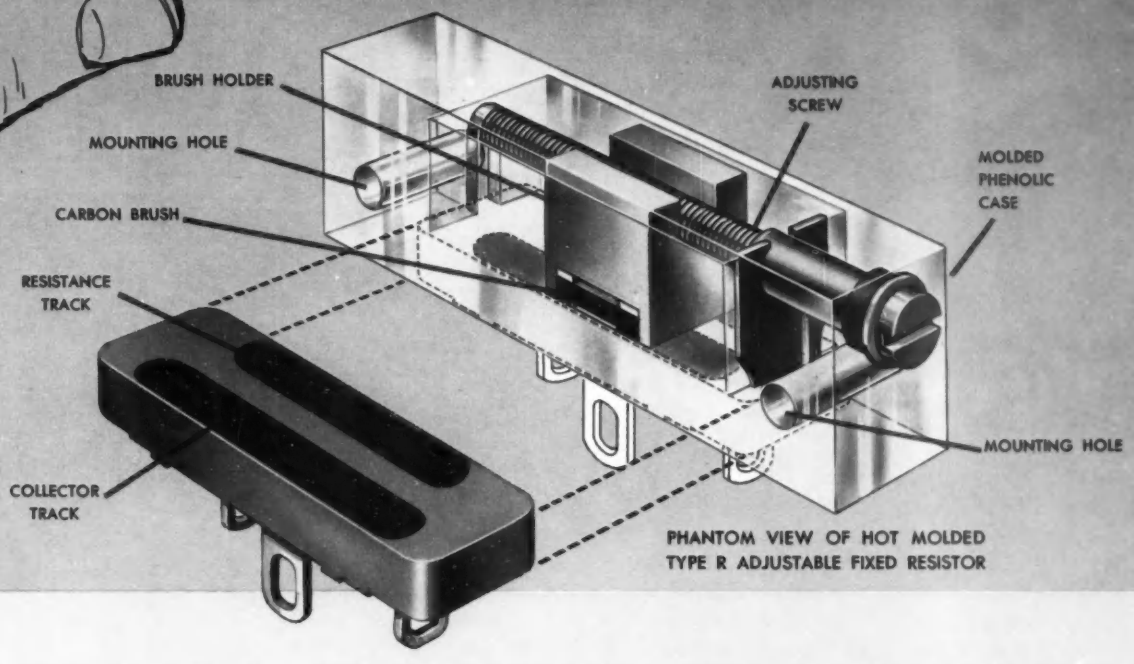
(Continued on page 184)

CIRCLE 62 ON READER-SERVICE CARD →



NEW ALLEN-BRADLEY

Adjustable Fixed Resistor



PHANTOM VIEW OF HOT MOLDED TYPE R ADJUSTABLE FIXED RESISTOR

Exclusive hot molded dual track resistance element and carbon brush give unmatched reliability and long life

SPECIFICATIONS

Power Rating: ¼ watt at 70°C ambient
Voltage Rating: 350 volts maximum
Temperature Range: −55°C to 120°C
Resistance Range: total resistance values from 100 ohms to 2.5 megohms ±10% or ±20%
Adjustment: approximately 25 turns
Dimensions: approximately 1¼" x 21/64" x ¼"
Terminals: lug and pin type terminals on 0.1" grid system and are gold plated for ease of soldering.

Here's a new, compact, adjustable fixed resistor—the Type R—with Allen-Bradley's exclusive hot molded resistance element. It's the same type resistance element used in the popular Type J and Type G units . . . which have proved unequaled for reliability and long life. Operation is exceptionally smooth—no abrupt resistance changes occur with adjustment. The molded case of the Type R adjustable fixed resistor is watertight and dust-tight. The mounting for the moving element is self-locking to assure stable setting—and the entire unit can be "potted" after adjusting. The adjustment screw has a "free wheeling" clutch to prevent damage.

Send for complete information on this latest addition to the Allen-Bradley line of *quality* potentiometers.

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

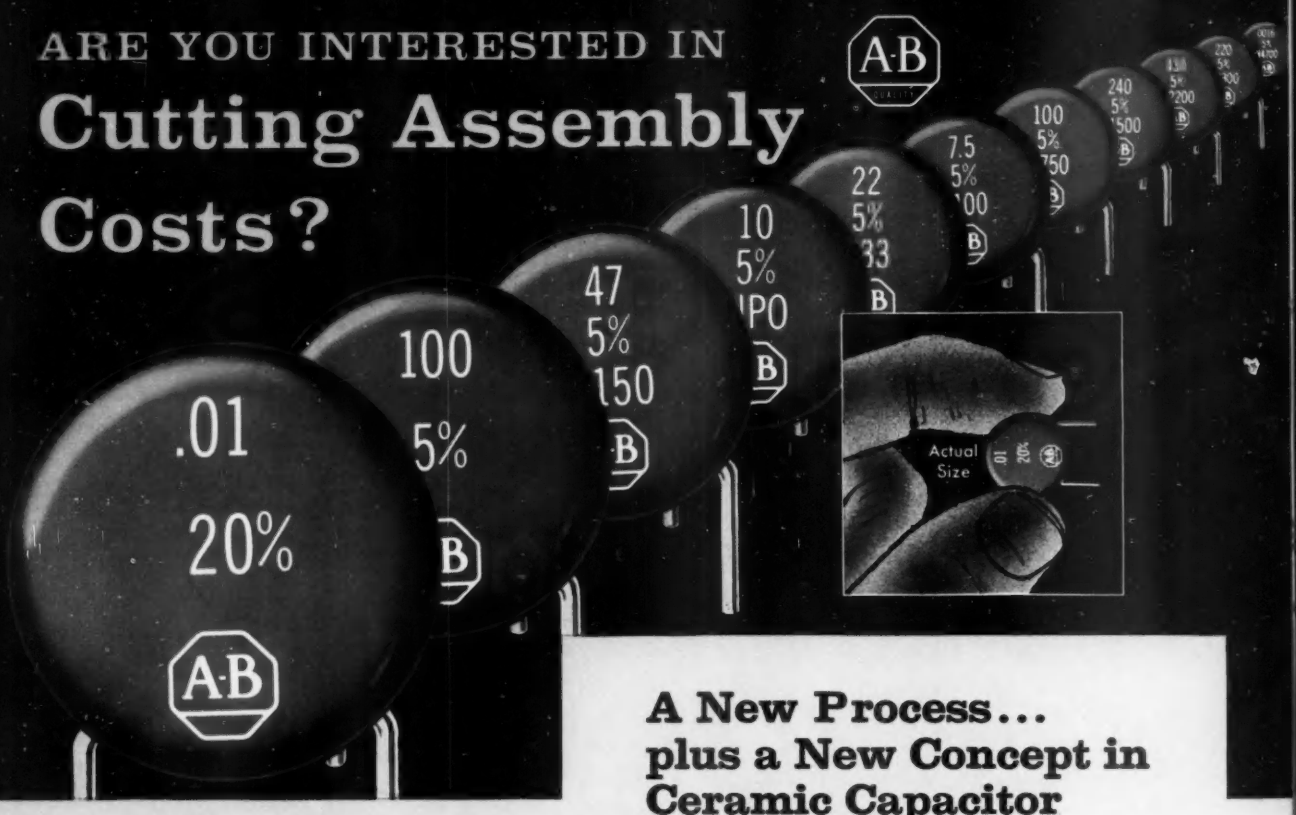
A-B QUALITY

ALLEN-BRADLEY

QUALITY
ELECTRONIC COMPONENTS

2-59.1

ARE YOU INTERESTED IN Cutting Assembly Costs?



A New Process... plus a New Concept in Ceramic Capacitor Standardization!

... provides superlative electrical properties

Standardization on only *one size* of capacitor—0.55" diam—for most values, permits scientific selection of ceramic materials with the *optimum* dielectric constant for *each* capacitance value. Through such advanced design technique, Allen-Bradley Type A ceramic capacitors provide greater dielectric strength and greater breakdown voltage . . . creepage paths are also increased. In addition, the coefficients of temperature, frequency, and voltage are lower . . . and the power factor is lower, too.

Allen-Bradley's standardizing on *one size* for all capacitance values has produced a *superior* capacitor that can be assembled by machines on printed boards at lower cost. Manual assembly costs are reduced, and capacitor inventory costs are also reduced.

Allen-Bradley Type A capacitors are available in general purpose, stable, and temperature compensating types in the most frequently used values. Send for new data sheets.

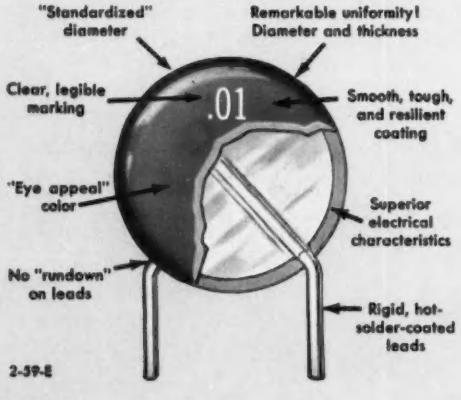
Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

New "Auto-Coat process" makes high speed machine assembly possible—but it also makes manual assembly quicker—at lower cost!

Allen-Bradley's new "Auto-Coat process" provides a tough, smooth insulating coating of uniform thickness—it does not use wax or other sticky impregnants which are bound to clog automatic machines. The physical uniformity of these capacitors permits accurate mechanical or manual insertion on printed boards.

With "rundown" on leads eliminated, the capacitor is permitted to rest directly on printed boards—for solid, three-point mounting. Costly cleaning or crimping of wires to prevent soldering failures is a nightmare of the past; lead inductance is less.

Allen-Bradley Type A Ceramic Capacitor

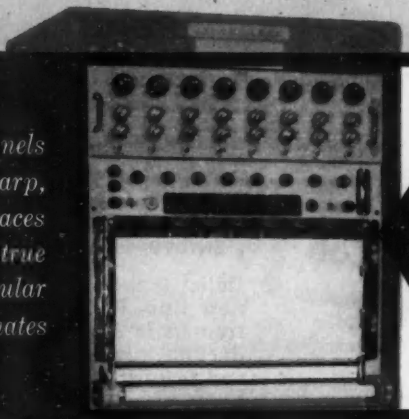


ALLEN-BRADLEY
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QUALITY

ALL THIS

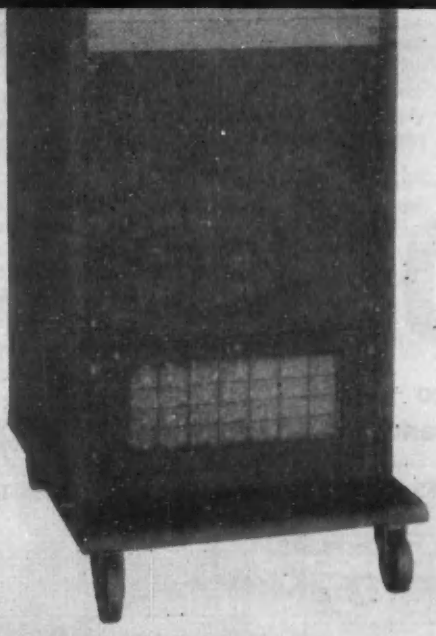
- LINEARITY 0.5% OF FULL-SCALE
- COMPLETELY TRANSISTORIZED
- CURRENT FEEDBACK AMPLIFIERS
- VELOCITY FEEDBACK DAMPING
- GAIN STABILITY BETTER THAN 1%
- 9 ELECTRICALLY CONTROLLED CHART SPEEDS

6 or 8 channels of sharp, inkless traces in true rectangular coordinates



in a new, simplified...

5-VOLT FULL-SCALE SANBORN RECORDING SYSTEM



8-Channel Model 358-5480 Oscillographic Recording System . . . 6-Channel Model 356-5480 also available.

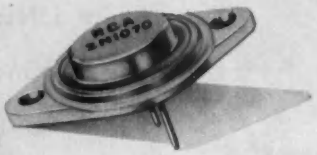
This new Sanborn direct writing system provides six or eight channels for computer readout, telemetry recording, DC voltage monitoring and similar applications where 0.1 volt/div sensitivity is sufficient and no preamplification is needed. The input impedance is 100,000 ohms. Frequency response is 3 db down at 100 cps at 10 div peak-to-peak amplitude; hysteresis is less than ±0.1 div. A 17½" Recorder-Amplifier-Power Supply package displays 8" of chart, locks in or out, loads easily from the front, has a built-in footage indicator and take-up, and can be completely remote-controlled. Galvanometers are rugged, low impedance, low voltage units with enclosed construction. The 5¼" Control Panel provides front and rear inputs, attenuator ratios of 1, 2, 5, 20 and 50, internal 2-volt calibration signals, position and smooth gain controls. The system is available in either the 60" mobile cabinet as shown (complete with power panel, wiring harness and built-in blower) — or as separate Recorder-Amplifier-Power Supply and Control Panel units for rack mounting.

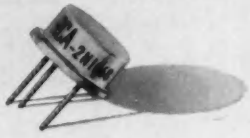
Find out what this new system can do for *you*. Ask your local Sanborn Industrial Sales-Engineering Representative for complete facts — or write the Industrial Division in Waltham.

SANBORN COMPANY
175 Wyman Street, Waltham 54, Mass.

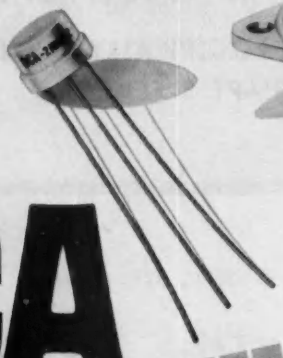
CIRCLE 63 ON READER-SERVICE CARD

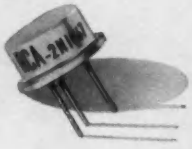
NOW...











RCA Silicon Transistors

DIFFUSED-JUNCTION MESA

...with excellent beta stability from −65°C to +175°C and exceptionally low saturation resistance!

- **2N1092—medium power**
- **2N1067—intermediate power**
- **2N1068—intermediate power**
- **2N1069—high power**
- **2N1070—high power**

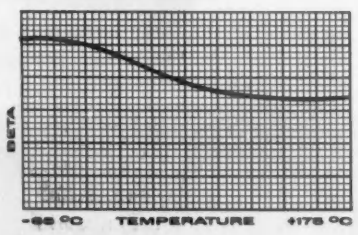
Initial types in an outstanding new line—RCA n-p-n silicon transistors offer significant reductions in saturation resistance, and feature excellent beta stability over the entire operating temperature range. These features result from use of RCA's advanced diffused-junction mesa technique. These transistors are designed to meet stringent military, environmental, mechanical, and life test requirements.

RCA silicon transistors offer the equipment designer a wide choice of power-switching capability in industry-preferred cases (JEDEC TO-3, TO-5, & TO-8).

RCA SILICON TRANSISTORS are commercially available in limited quantities through your Authorized RCA Semiconductor Distributor. For technical data contact him. Or, write RCA Commercial Engineering, Section D-56-5D, Harrison, New Jersey.

Type	JEDEC Outline	ABSOLUTE-MAXIMUM RATINGS: V_{CES}* (volts)	V_{CEO}▲ (volts)	Collector (amp.)	Transistor Dissip. # (watts)	CHARACTERISTICS: At Case Temperature of 25°C — Saturation Resistance (ohms): Typical	Max.	Conditions	DC Current Gain (Beta): Typical	Min.	Conditions	At Case Temperature of 175°C — DC Collector Cutoff Current (I_{CBO}) (μa): Typical	Max.	Conditions
2N1092,	TO-5	60	30	0.5	1	3	10	I_C=200 ma.	20	10	I_C=200 ma.	75	1000	V_{CBO}=30 volts
2N1067	TO-8■	60	30	0.5	2.5	3	10	I_C=200 ma.	35	15	I_C=200 ma.	75	1000	V_{CBO}=30 volts
2N1068	TO-8■	60	30	1.5	5	1	2.67	I_C=750 ma.	38	15	I_C=750 ma.	75	1000	V_{CBO}=30 volts
2N1069	TO-3	60	45	4	25	0.7	2	I_C=1.5 amp.	20	10	I_C=1.5 amp.	150	2000	V_{CBO}=30 volts
2N1070	TO-3	60	45	4	25	0.4	0.67	I_C=1.5 amp.	20	10	I_C=1.5 amp.	150	2000	V_{CBO}=30 volts

■ "Heat-Sink" mounting clamp supplied.
* Collector-to-emitter breakdown voltage with base connected to emitter.
▲ Collector-to-emitter breakdown voltage with base open.
At a case temperature of 100°C.



RADIO CORPORATION OF AMERICA
Semiconductor Products **Distributor Sales**
Harrison, N. J.

AVAILABLE AT YOUR RCA SEMICONDUCTOR DISTRIBUTOR!

THE LINK BETWEEN ELECTRONIC CONTROL AND HYDRAULIC POWER

Expert Welding Machine Co. Solves the High Production Contour Welding Problem With

VICKERS.

Electro-Hydraulic Servo Valve

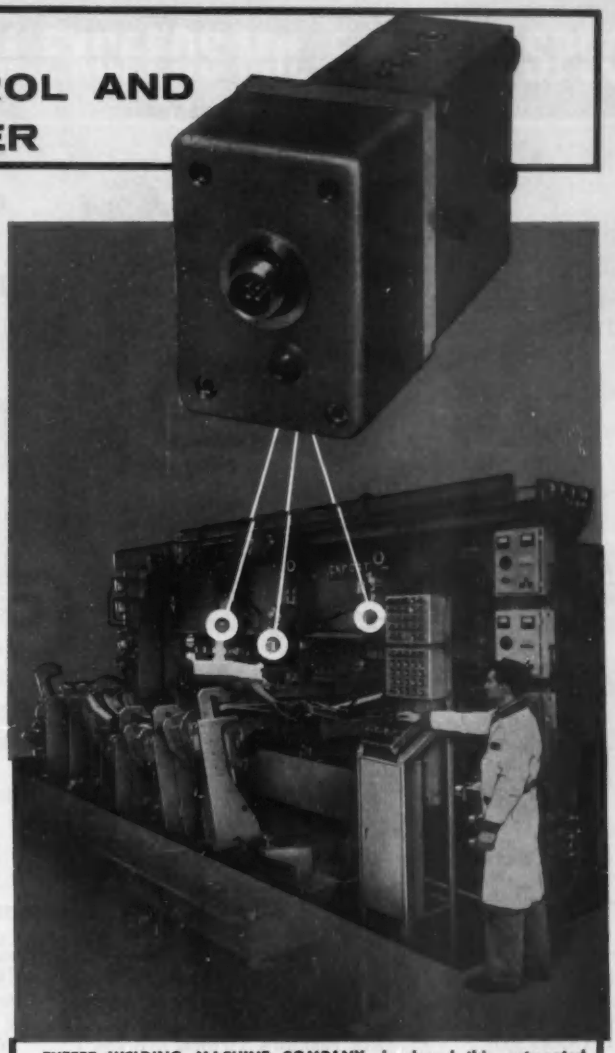
The versatility of electro-hydraulic control of power has solved one of industry's toughest problems — automatic welding of complex and contoured automotive frame members.

An electronic probe follows the weld line on the work and records any deviation from the path prescribed by a master cam. Any deviation from the governing cam contour creates an error signal which is amplified and fed to the servo valve. The servo valve converts these electrical signals into precise hydraulic flow to a cylinder which accurately positions the welding head allowing for variations in manufacturing operations . . . trimming, etc.

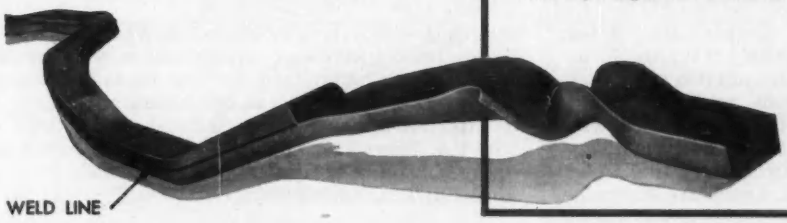
This application is only one of many in which Vickers Servo Valve has demonstrated exceptional performance under the exacting conditions of industrial production requirements.

Valve operation is simple. Reliability is assured—there are only four moving parts.

Investigate the production advantages offered by electro-hydraulics. **Write for Vickers Engineering Bulletin 58-74.**



EXPERT WELDING MACHINE COMPANY developed this automated welding machine that incorporates a magnetic-tape-tracer system. Vickers electro-hydraulic servo valve provides the link between electronic programming and hydraulic power. Vickers Pumps and Controls also used. The machine joins metal parts having untrimmed, out-of-tolerance, straight and/or contoured weld line edges.



Two U-shape channels are welded to form the box configuration in this complex automotive frame side member. Production is approximately 100 pcs/hr.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1606 • Detroit 32, Michigan

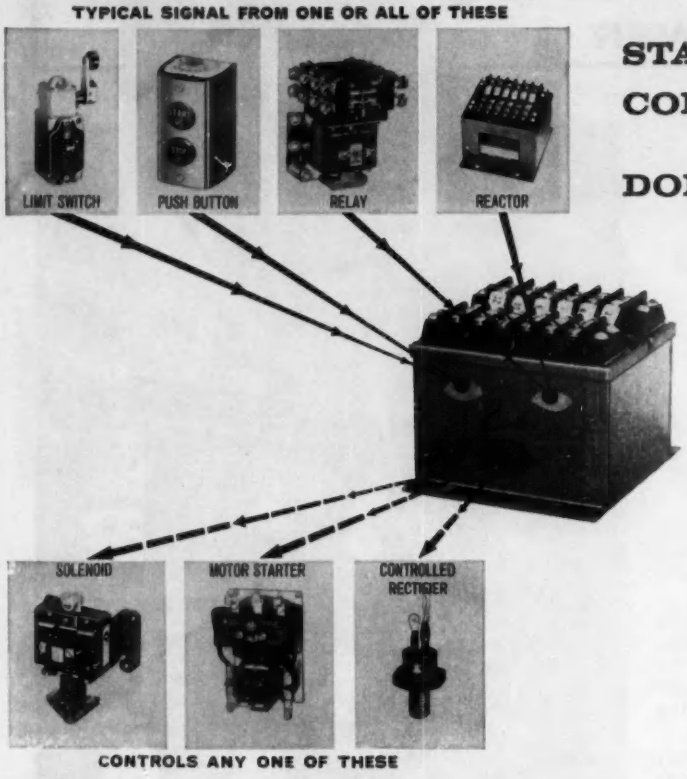
8259

Application Engineering Offices: ATLANTA • CHICAGO* • CINCINNATI • CLEVELAND • DETROIT* • GRAND RAPIDS • HOUSTON • INDIANAPOLIS • LOS ANGELES AREA (El Segundo)* • MILWAUKEE • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.)* • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE* • ST. LOUIS • TULSA • WORCESTER • Factories also in: Australia, England, Japan and Germany • In Canada: Vickers-Sperry of Canada, Ltd., Toronto,* Montreal and Vancouver
Field Service Headquarters Underlined. Whse. Stock & Repair Branches*.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time



STATIC CONTROL COMPLICATED?

DON'T YOU BELIEVE IT!

An engineering friend of ours working on blast furnace controls uses a CONTROL switching reactor to take signals from a series of limit switches, temperature controllers, and relays to operate the solenoid which triggers the air blast motor. Dollars ahead he was when he saw this *selective* device would take signals from many sources, compile them, remember them, and when told to act (by the same standard input signals), leap into action. "So simple," he said—"nothing but the standard inputs we always use, switching reactor and outputs. If that's static control, I'm the new president of the C.S.R* Booster Club." *You, too, can beat the drum. Write for our catalog about Simple Static Control.*

**CONTROL Switching Reactor*

PUSH, PULL, CLICK, CLICK *(or how to feed a switching reactor)*

Persons who hear push-pull-click-click sounds in industrial plants are not to be suspected of an affinity for the razor business. They are listening to the music of push buttons, limit switches and relays, all feeding signals into CONTROL'S switching reactors (which are engaged in static control). Our reactor is *selective.* As you dictate, it responds to control voltages which add, which oppose, or which work in combination, regardless of source. What's more, our reactor can be fed by a transducer whose output is electrical—even if it doesn't say "push, pull" or "click, click."

If you have an affinity for money-making musical sounds, perhaps you'd like to know more about these CONTROL switching reactors. Write us.

CLICK, CLICK, PULL, PUSH *(or how a switching reactor feeds you)*

Here is the click-click-pull-push (output) side of the CONTROL switching reactor. Not only is it *selective* as to source and combinations of inputs, but it is a real bear for working such loads as solenoids, motor contactors and magnetic clutches. It shines, too, as a practical way of operating the new solid state thyratron from a variety of input sources. A reactor can control a single load up to 300-VA to a fare-thee-well. Loads are statically switched with nary a moving part. What's more, there is no auxiliary hardware (transformers, relays or single purpose logic units) to clutter the minds and hearts of your control engineers and purchasing agents.

Sizes? A complete range, including 15, 75, 150, and 300 VA. There's also one especially for the solid state thyratron. Why not write for more details about our CONTROL switching reactors.

Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC.

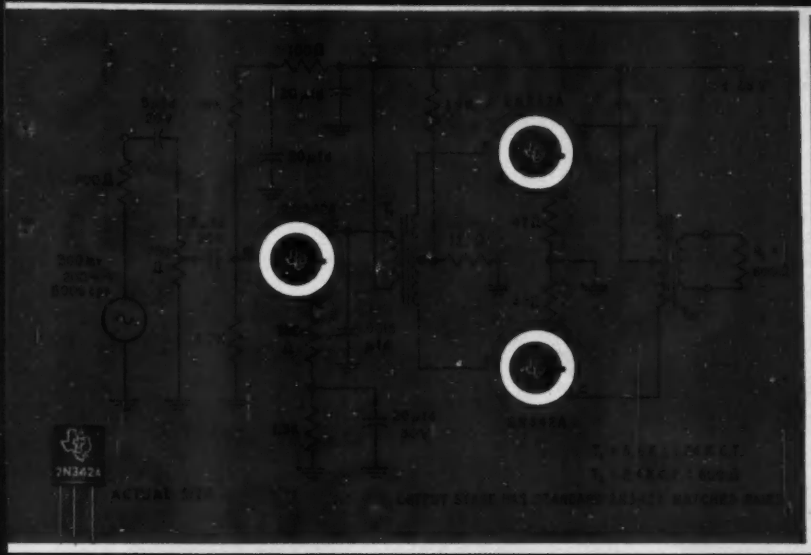
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CIRCLE 65 ON READER-SERVICE CARD

CIRCLE 66 ON READER-SERVICE CARD

TI Silicon Transistor Application Note

TRANSISTORIZED INTERCOM EXCEEDS MIL-E-5272B SPECS



CIRCUIT SPECIFICATIONS

150-mw output from -55°C to 100°C at less than 10% harmonic distortion over frequency range

Frequency response @ 25°C stable within ±2 db of 1000 cps 100 mw reference level from 200 to 8000 cps

Frequency response @ -55°C and 100°C within ±3 db of 25°C frequency response

Less than 3-db gain variation @ -55°C and 100°C compared to 25°C measurement

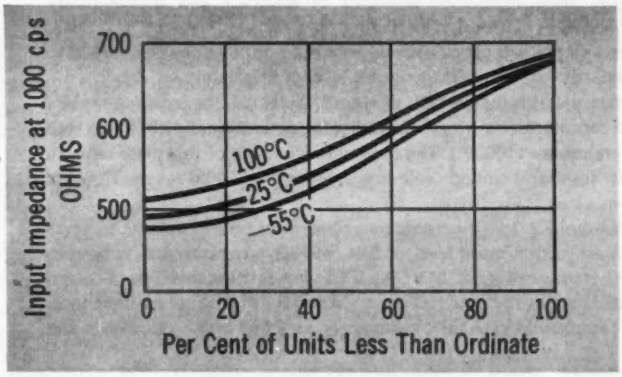
LOUD AND CLEAR AT 100°C!

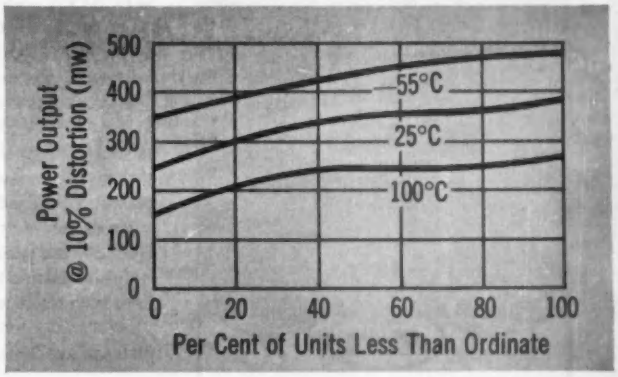
. . . with TI 2N342A silicon transistors from stock

You can satisfy the 71°C equipment requirements of MIL-E-5272B at 100°C with the intercom amplifier circuit shown above — using TI 2N342A silicon transistors with . . . guaranteed 3-to-1 linear beta characteristics . . . 85-v collector-to-emitter breakdown, giving a wide safety range with 28-v aircraft supplies . . . plus dissipation capability of 1 watt at 25°C and 200 mw at 125°C.

The newest addition to the *use-proved* TI 2N339 series introduced in 1957, this medium-power unit carries the full-year TI guarantee and is immediately available *off-the-shelf* from all TI distributors in 1-249 quantities. For production quantities, contact your nearest TI sales office.

TYPICAL INTERCOM AMPLIFIER PERFORMANCE CHARACTERISTICS USING 2N342A TRANSISTORS





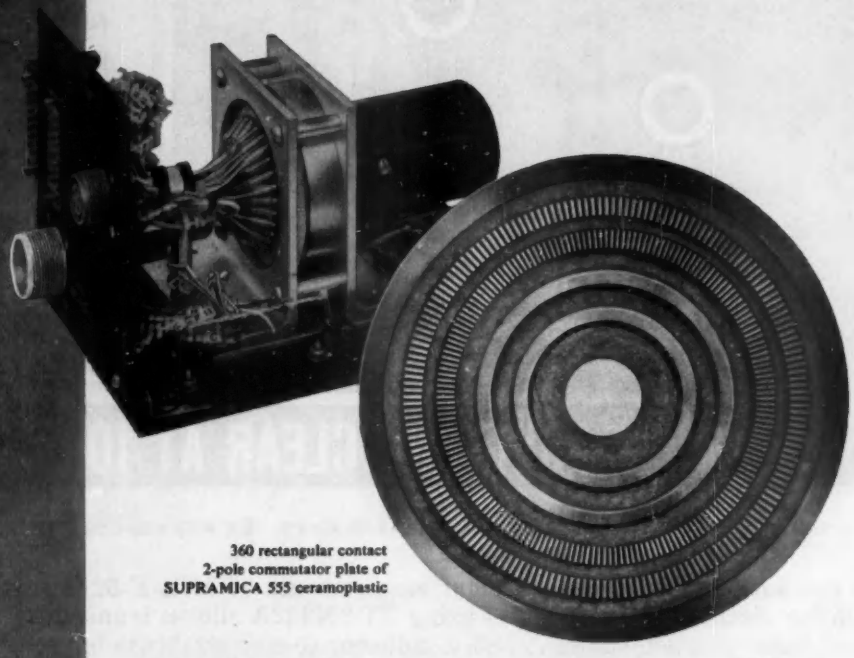


from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 312 · 13500 N. CENTRAL EXPRESSWAY
DALLAS, TEXAS

major advance in miniaturization:

SUPRAMICA® 555 commutator plates



360 rectangular contact
2-pole commutator plate of
SUPRAMICA 555 ceramoplastic

on a 3 inch precision-molded plate ...up to 540 rectangular contacts!

Since 1948 . . . when Mycalex Electronics Corporation pioneered the first *precision-molded* MYCALEX® 410 glass-bonded mica, 180-contact commutator plate . . . MYCALEX switches have introduced a degree of accuracy and dependability never before approached in mechanical switching.

And now, Mycalex offers a *new* ceramoplastic commutator plate design destined to set *even higher* standards for long-life, low-noise-level multiplexing.

Typical of these new plates is the CP 427. Its specifications call for *precision-molded* SUPRAMICA 555 ceramoplastic which delivers total dimensional stability as well as superb thermal endurance (700°F.). The individual contacts of this plate have an exclusive *rectangular* form and embody tolerances within the .0005" range. They are permanently fixed in place.

An exclusive brush-holder design permits *lower pressures* on the wipers . . . gives *lower contact resistance* with a noise level of *less than 10 microvolts*. Brush bounce is eliminated and life greatly extended. MYCALEX switches using this type of design have been tested satisfactorily for over 1000 hours at 600 RPM without maintenance.

Information on complete MYCALEX switches or matched brush assemblies and plates is available.

General Offices and Plant: 127-B Clifton Blvd., Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N.Y.

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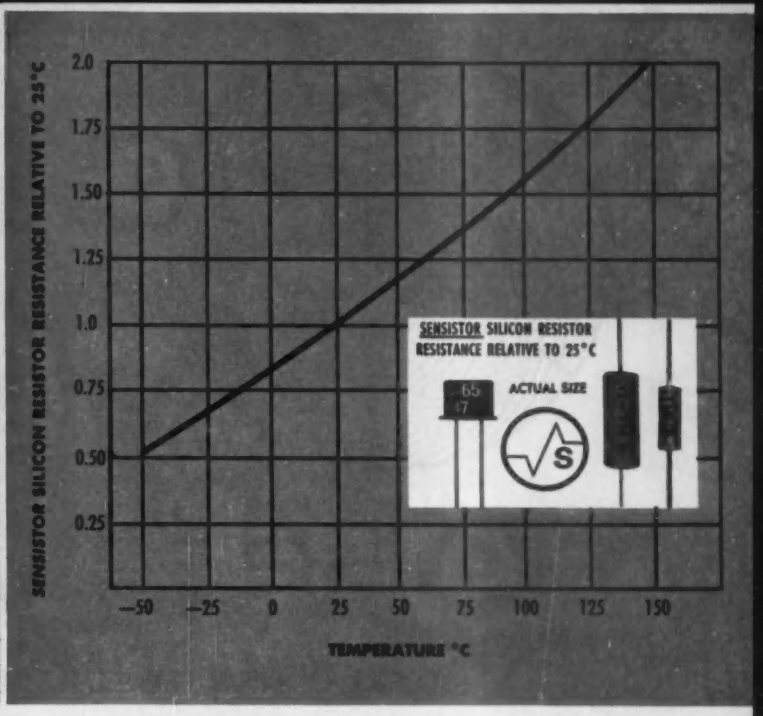
MYCALEX
ELECTRONICS CORPORATION

EXCLUSIVE LICENSEE OF MYCALEX CORPORATION OF AMERICA

CIRCLE 67 ON READER-SERVICE CARD CIRCLE 68 ON READER-SERVICE CARD→

TI APPLICATION NOTE





HOW TO INCREASE DIFFERENTIAL DC AMPLIFIER STABILITY WITH *sensistor** SILICON RESISTORS

Low drift transistor amplifier circuit using *sensistor* silicon resistor gives drift performance superior to vacuum tube amplifiers for low source impedance applications.

The sensistor silicon resistor has a unique positive temperature coefficient of +0.7%/°C plus a constant rate of change as shown in the graph to the right. Over a 15°C temperature range, the *sensistor* silicon resistor's temperature-resistance curve approaches linearity to an extent that allows its use as a compensating component in a differential D-C amplifier.

This low drift amplifier finds a wide range of low source impedance applications in airborne telemetry where the performance of other types of D-C amplifiers is limited by weight requirements, acceleration, shock, and vibration. It is particularly useful with low level transducers such as thermocouples, strain gages and accelerometers.

DESIGN CONSIDERATIONS

TI 2N338 silicon transistor provides excellent performance as a low drift DC amplifier when used in circuits such as the one shown above.

For optimum performance keep $(2R_s + R_x)$ as small as possible, preferably less than 2000Ω, and the collector currents of Q_1 and Q_2 should remain below 100 μA.

Drift cancellation featured in an uncompensated differential configuration provides an amplifier with an equivalent input drift of 400 μV/°C or less with standard production transistors.

Drifts as low as 6μV/°C will result if the compensating circuit composed of Q_3, sensistor resistor S and their biasing resistors is used with a matched pair of transistors.

CIRCUIT OPERATION

Sensistor resistor S and its biasing resistor R_s serve as a voltage source which has an output linearly related to temperature . . . level potentiometer R_x adjusts output voltage E_o to zero when E_{in} is zero . . . potentiometer R_4 adjusts for minimum output drift due to ambient temperature changes.

As temperature increases, the resistance value of S also increases causing the base of Q_2 to go more negative, thereby reducing the collector current of Q_2. This temperature-dependent current is fed into the differential amplifier through R_4.

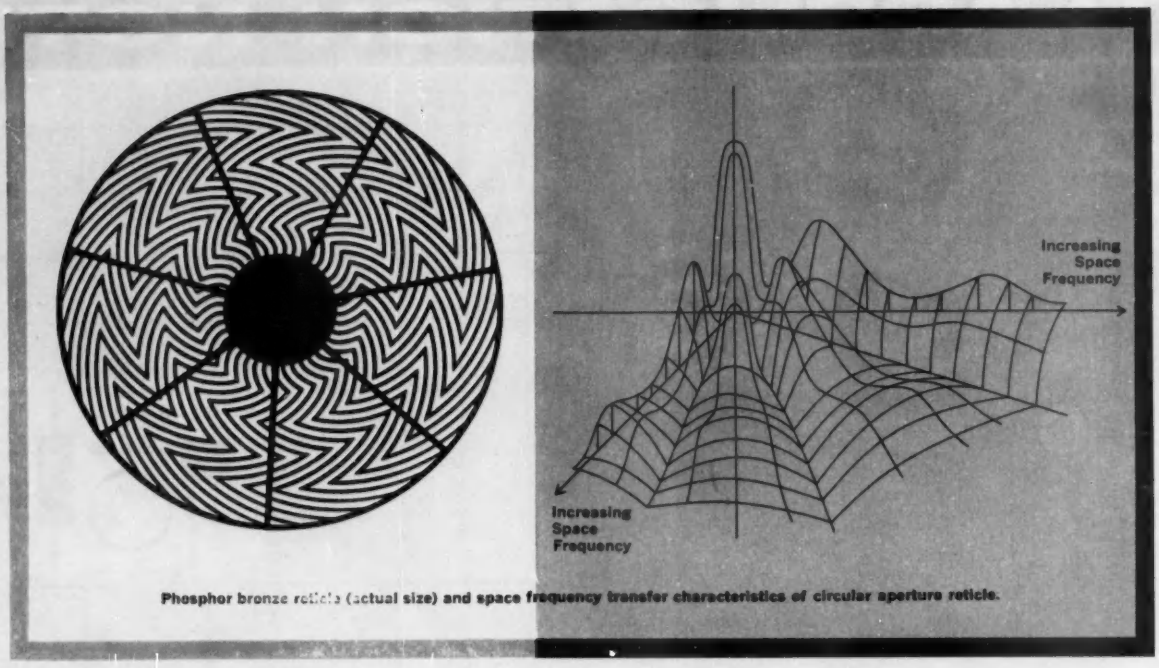
Depending on the wiper position of R_x, the correcting signal may be positive, negative or zero. When the wiper is centered, zero correction results. As temperature increases, output voltage E_o tends to go more positive if the R_4 wiper is placed nearer the Q_2 emitter and negative if the wiper is placed nearer Q_1. The optimum setting for R_4 can be determined by cycling over the desired temperature range to give a minimum drift for changes in ambient temperature.

*TRADEMARK OF TEXAS INSTRUMENTS



from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 312 • 13500 N. CENTRAL EXPRESSWAY
DALLAS, TEXAS



Phosphor bronze reticle (actual size) and space frequency transfer characteristics of circular aperture reticle.

TARGET DISCRIMINATION IN INFRARED DETECTION SYSTEMS

The pioneering field of infrared detection offers many challenging opportunities to scientists and engineers at Ramo-Wooldridge for advanced studies in the solution of target discrimination problems. Research is continually under way at Ramo-Wooldridge in the integrating of infrared detection devices with the latest electronic systems techniques for enhanced target detection on the ground and in the air.

The phosphor bronze reticle, or image chopper, illustrated above was developed by Ramo-Wooldridge. It indicates a marked stride in space filtering discrimination concepts, and is used for target signal enhancement in guided missiles, anti-aircraft fire control and air collision warning applications.

The reticle is used in the focal plane of an infrared optical system and is rotated to chop the target image for the desired space filtering. It is also employed in time filtering, such as pulse length discrimination, or pulse bandwidth filtering.

Space filtering is critical to infrared systems, because of its ability to improve the detection of objects located in the midst of background interference. In a manner similar to that used in the modification of electronic waveforms by electrical filtering, space filtering enhances the two-dimensional space characteristics of a target. The size and features of the target are highlighted and the undesired background eliminated.

Scientists and engineers with backgrounds in infrared systems—or any of the other important areas of research and development listed below—are invited to inquire about current opportunities at Ramo-Wooldridge.

Electronic reconnaissance and countermeasures systems
Analog and digital computers
Air navigation and traffic control
Antisubmarine warfare
Basic research
Electronic language translation
Information processing systems
Advanced radio and wireline communications
Missile electronics systems

RAMO-WOOLDRIDGE
P.O. BOX 90534 AIRPORT STATION • LOS ANGELES 45, CALIFORNIA
a division of *Thompson Ramo Wooldridge Inc.*

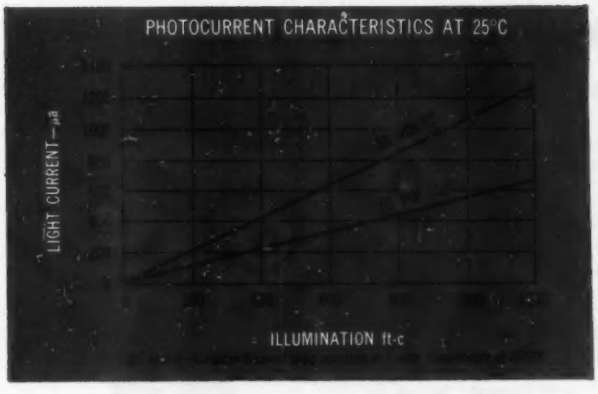
from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

NEW FROM TI

1N2175 SILICON PHOTO-DEVICE SWITCHES FROM DARK TO LIGHT CURRENT IN 2 MICROSECONDS



TI 1N2175 subminiature unit is ideal for punch-card or tape data processing, and many other control systems



Now you can get quadrupled sensitivity and unprecedented design flexibility with the new subminiature TI 1N2175 Photo-Device.

Easily activated, the 1N2175 switches from a low dark current of only 0.5 μa to a high light current of 1200 μa at 1200 ft-candles — *within 2 μsecs.* Rated at 250 mw at 25°C, the 1N2175 operates over a range of 1-50 volts, and derates linearly to 125°C. Minimum operating temperature is –55°C.

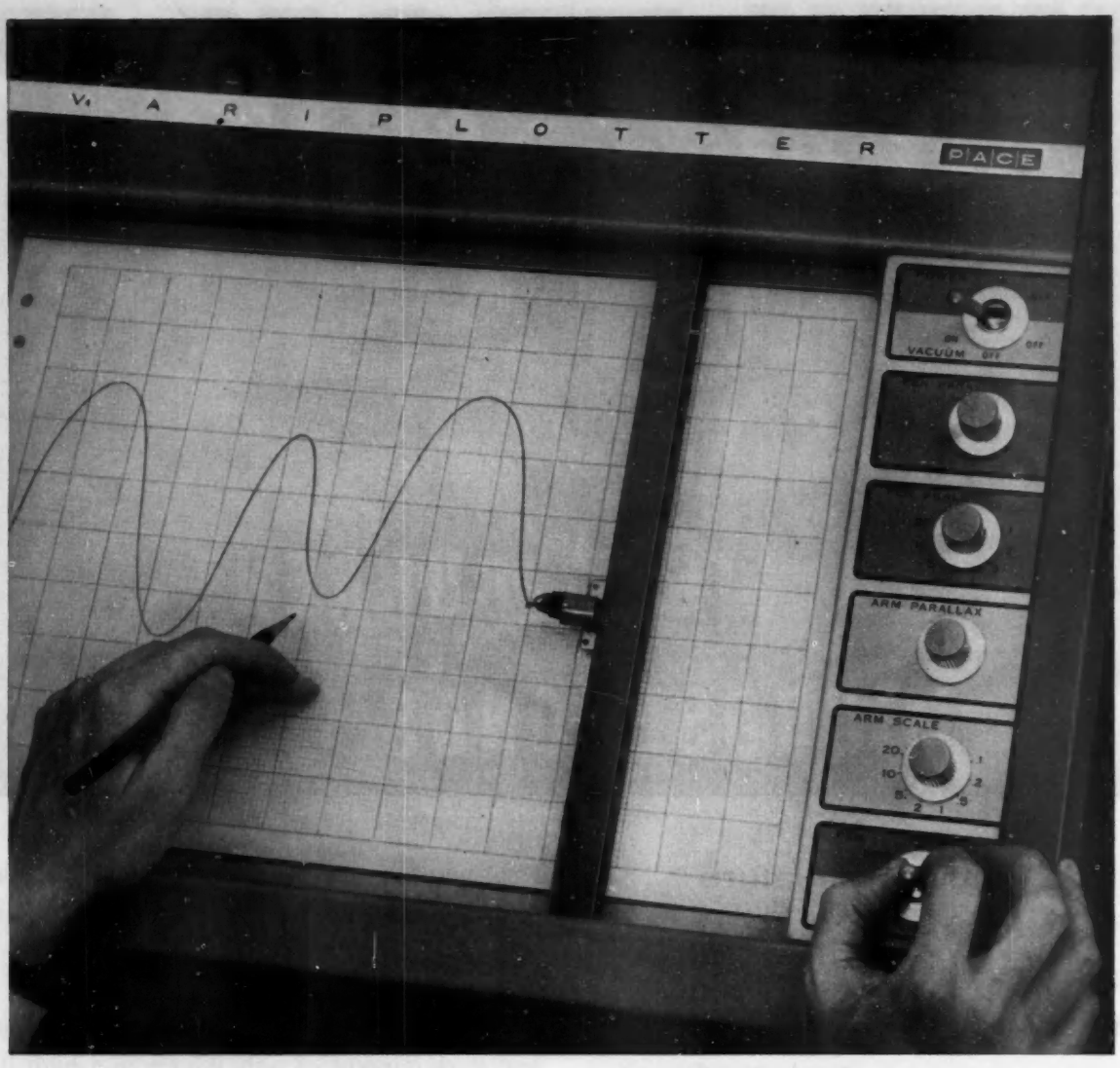
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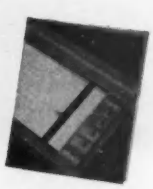
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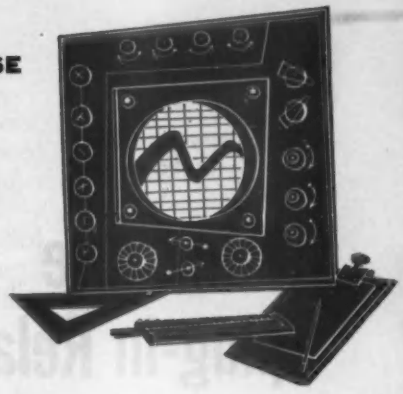
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Market Battle Looms:
Power Transistors vs. Solid-State Thyratrons

In the last two years, transistor sales to the control field have surged upward. The development of power transistors capable of handling control-size currents and wattages opened up broad industrial and military markets; and today at least 13 companies are making some kind of power transistor.

pnpn threat

Now there's a threat to this rising sales curve. Solid-state thyratrons—also known as pnpn switches or controlled-silicon rectifiers—are staking out some of the applications which power transistors have carefully cultivated.

In control circuitry, power transistors have usually been called on to do either of two functions: 1) modulate power or 2) switch a circuit load. Power-handling capabilities are growing at a staggering rate. Only a few years ago, transistor wattage was defined in milliwatts. Today, transistors like Texas Instruments' type 2N1047 can dissipate 40 watts at 25 deg C in power-modulating applications. And Bendix Aircraft Corp.'s new 2N1073 can switch up to 1,200 watts (10 amps at 120 volts).

Two new transistor developments

Two new transistor developments, revealed at the Solid State Conference in February, indicate the kind of progress under way. In announcing the 2N1073, Bendix pointed out that it was a diffused alloy germanium transistor; its switching speed was less than 1 microsec, and it could handle a peak current of 20 amps. At the same time, Westinghouse announced availability of a new silicon power transistor, the WX1015 (and the WX1016). This device, which can be used as a linear amplifier, handles 2 amps at 120 volts with a current gain of at least 10. The next unit, said a Westinghouse engineer. will carry 20 amps.

The key applications of power transistors to-date have been in high-voltage (100-120 volts) power converters, amplifiers, and switching circuits, which require low distortion, linear trans-conductance, low saturation resistance, or fast switching times; relay drivers and computer core driver applications; horizontal and vertical cathode-ray-tube deflection circuits, where high-frequency capability is required as well as high power; and high-power mobile applications, where high frequency response is important.

Into this picture, the solid-state thyratron burst in November 1957. General Electric announced that it had converted a Bell Telephone Laboratory design into hardware, had named it the silicon controlled rectifier. Over the next year, while GE production engineers rushed to make two models of the controlled rectifier commercially available (10-amp and 16-amp units) a GE

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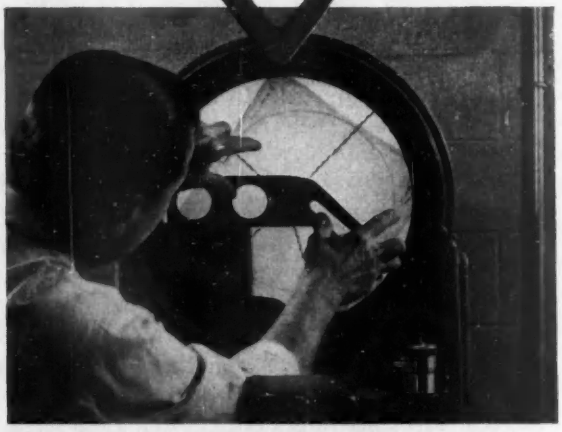


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task force strove to uncover applications for the new device.

Advantages of thyratrons

Many of the applications turned out to be those already serviced by power transistors. But GE found that its controlled rectifier had three advantages over the power transistor:

- current is distributed uniformly throughout the controlled rectifier; in a power transistor, ring has to carry all the current. This means it is easier to build higher-rated controlled rectifiers than power transistors.
- the speed of the controlled rectifier makes even the new fast-power transistor seem slow. Rise time for the former, for example, are in the order of 100 millimicrosec or better.
- the controlled rectifier is easy to protect; it stays in saturation with an overload; fuses blow first.

At first glance, it would appear that the new solid-state thyratron will take over the market completely from the power transistor. But the transistor still has a flock of applications that it serves better. One example: series-regulated power supplies. The power transistor always allows positive control—it can be turned on or off without removal of applied voltage or reduction of forward current.

There's a feeling that each type of device has its own best area of application—with a grey area of overlap. The pnpn triode seems best suited for high-power switching applications; the power transistor appears better suited in many modulating jobs.

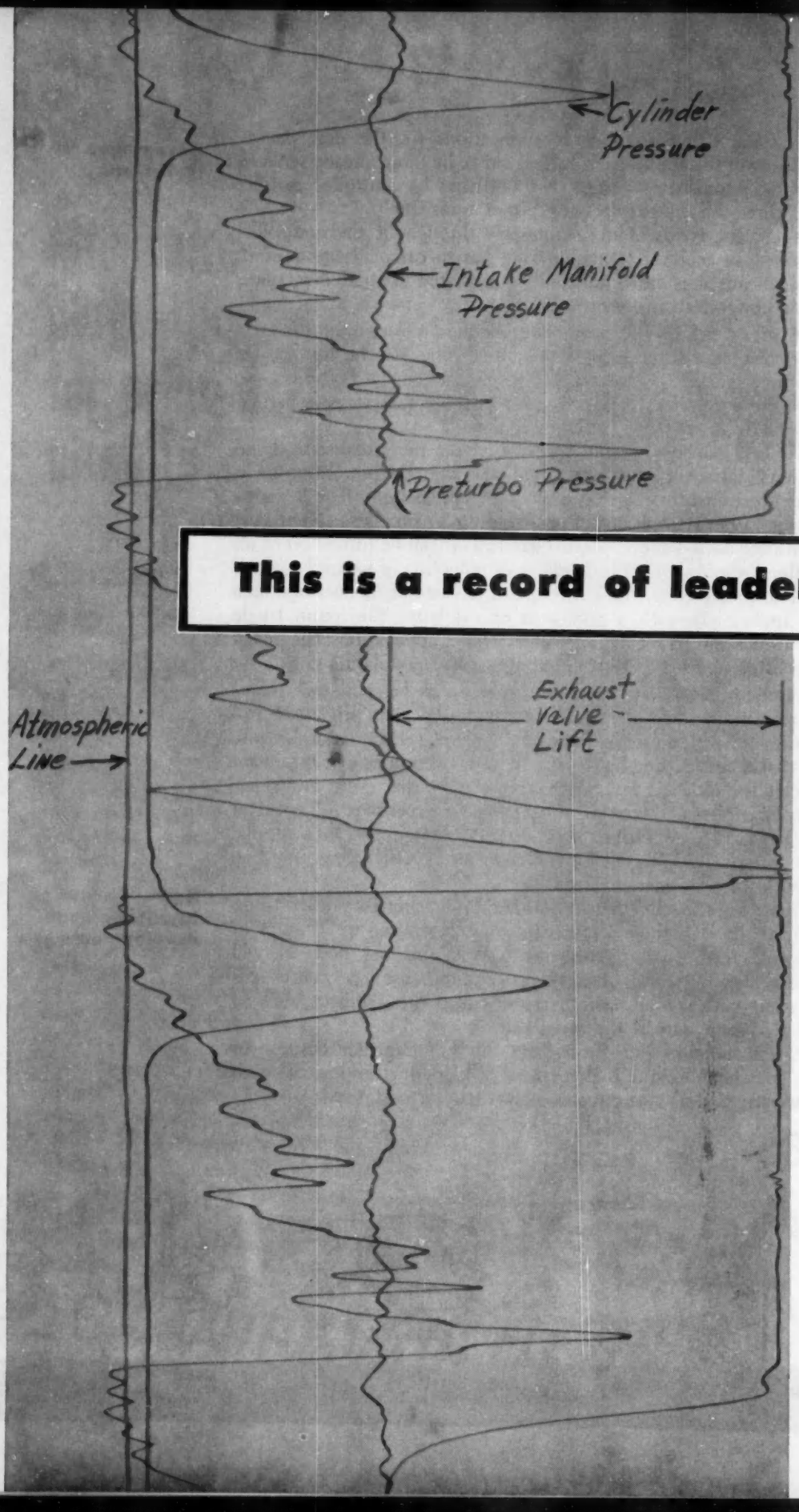
A major limitation of the pnpn switch may be economic. Most transistor manufacturers feel that the solid state thyratron will always be "a little more expensive" than a power transistor. Despite extensive cost-cutting by GE (there were seven price cuts on silicon controlled rectifiers last year, the first year they were available), the controlled rectifier is still relatively expensive. Transistor makers have been slashing costs, too. Westinghouse, for example, announced a 30-percent price cut on its WX1015 line only two months after it was announced.

New thyratron developments

But pnpn developments continue. GE, showed off a 50-amp unit at the IRE show, expects to boost the rating to 70 amps in a few months. Commercial quantities of this one, however, will not be available until late spring. Westinghouse has been experimenting with a solid-state thyratron called the Trinistor, showed off a 35-amp unit at the same show.

Users stand to gain most from this looming race because of the inevitable result: higher-power semiconductor devices—both power transistors and pnpn triodes—at lower cost.





This is a record of leadership

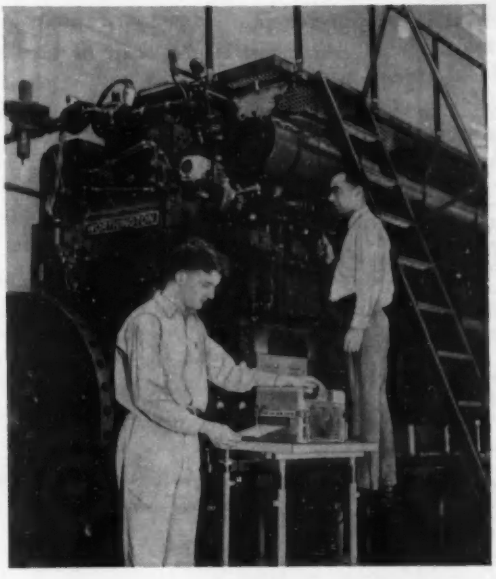
The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

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Analysis of these data has led to changes in the Tripower engine for best performance.

in diesel engine research



Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tripower with a Honeywell 906 Visicorder.

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5,460,000	600	1	ELECTRONICS, Oct. 1, 1957, pg. 167
1,250,000	125	0	PHILCO REPORT, Feb. 10, 1959
16,000,000	10,192	2	WJCC REPORT, Feb. 1957
8,640,000	8,000	2	PHILCO REPORT, Feb. 12, 1959
19,196,232	18,601	3	PHILCO REPORT, Nov. 19, 1958

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*Documented service hours in these six computers only. Total transistors hours in similar circuits are many times this amount.

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Control ENGINEERING

APRIL 1959

Imaginary Pigeonholes

Can an engineer adequately specify control systems without knowledge of their basic components, materials of construction, and principles of operation? Can a designer of system components successfully execute his designs without clear understanding of applications? Some of the people along the marketing stream have the notion that the answers are yes to both questions. They imagine an applications man in one pigeonhole, blithely hanging instruments and controls on a machine or process, ignorant of the design details of the control. And they see a design engineer in another pigeonhole, busily designing with little knowledge of how his design will be applied. All this is utterly unrealistic, for design and application must, in some way, feed on one another in the process of system engineering, all the way from the recognition of a problem, through specification of the equipment, to the follow-through that takes place when the system is tried out and adjusted.

Somewhere there probably are engineers specifying control products, who are so far removed from product design that they literally do "hang black boxes" on their processes; and somewhere, too, there are designers who go about their work with no application feedback. (We know for a fact that in the Soviet Union application techniques and product designs are standardized by government ministries. Products make up the only interchange between user and manufacturer.) But our business atmosphere puts a premium on individuality and initiative, and we welcome them from either manufacturer or user. We seek productivity by using control systems that give us the best balance between performance and cost; we are not afraid to pay the price of admission that comes with a radically new approach; we are aware that we gamble when we make control systems more complex and sophisticated, but the gamble is an educated one that more often than not pays off in integrated design and application.

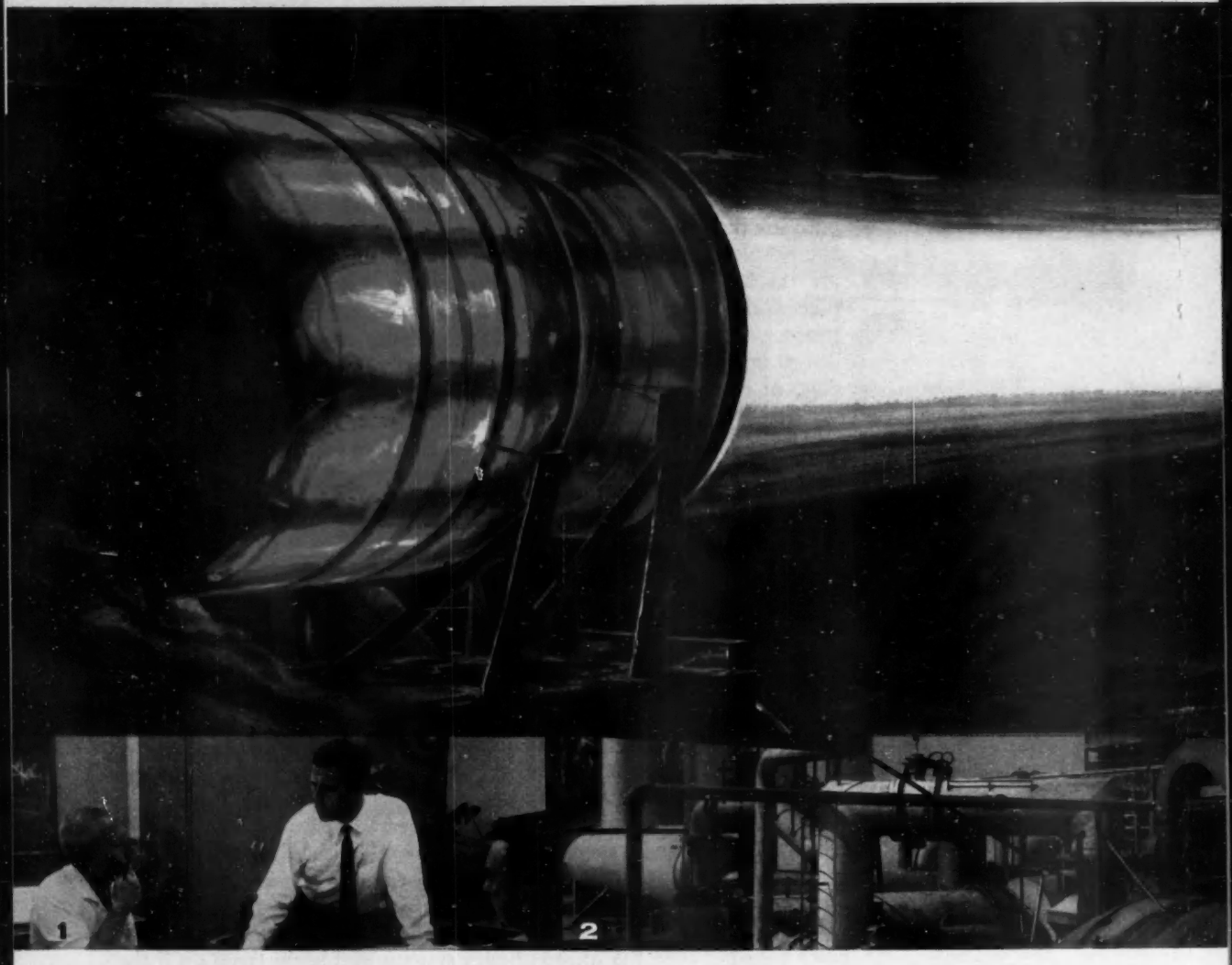
We copper the gamble with basic control hardware, the glue that holds together even the most complex systems and backs them up if they falter. Through the years this hardware has developed from interplay between manufacturer and user, working together to perfect application design.

W. E. Vannah

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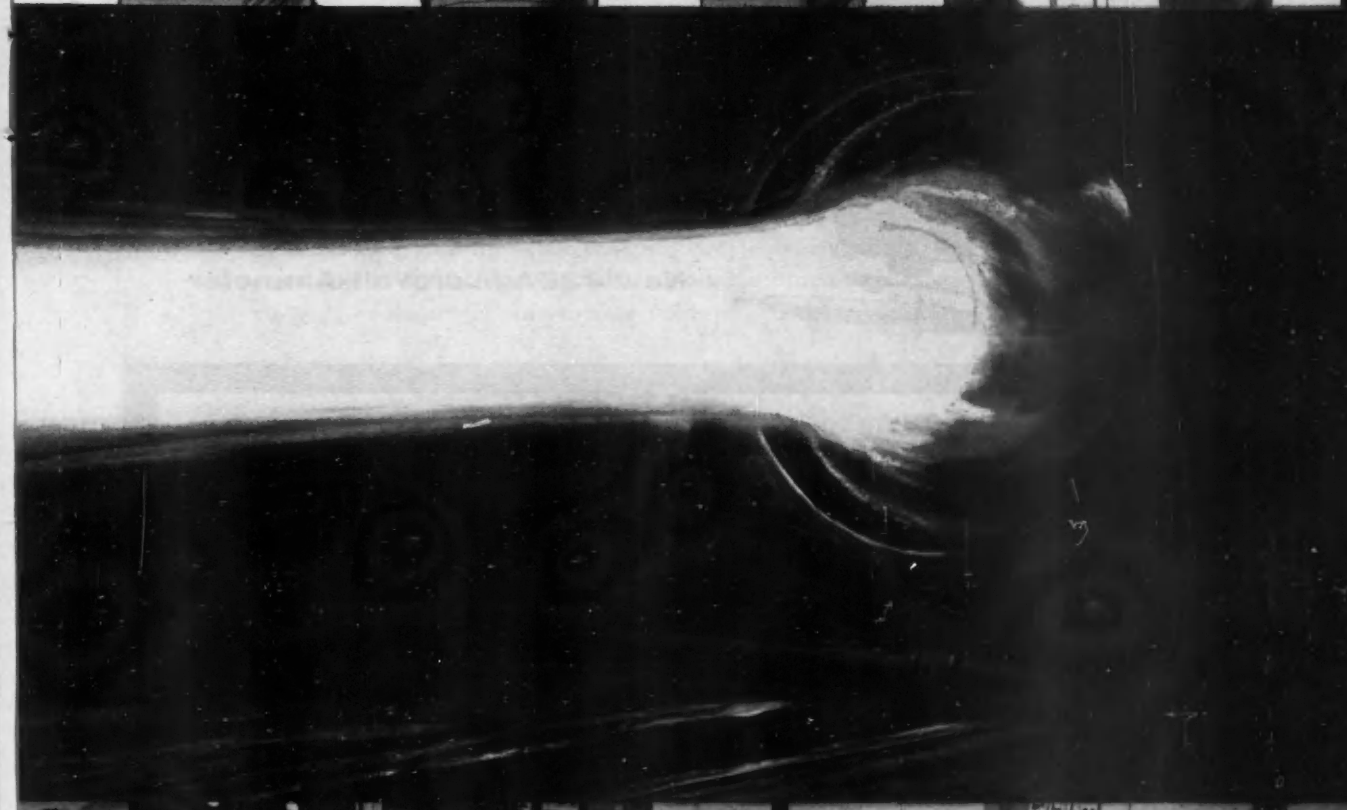
Test facilities conceived, designed, developed, and operated by Marquardt Aircraft—which include the USAF-Marquardt Jet Laboratory and test installations of the U. S. Navy—perform an important role in the development of advanced propulsion systems, controls and accessories for air and space operations. Here, in a creative engineering environment, professional engineers specializing in analysis, design, and operation of test equipment are constantly challenged by the complex requirements which must be satisfied to support critical development programs, including test support for long-range space research projects currently underway. Simulation of high altitude engine and equipment operating conditions, handling and testing with new chemical fuels, solving the problems of extreme temperatures and vibration, extrapolation of data for space applications, and recording test data under conditions never before simulated, are only a few of the research and development areas presently being explored by engineers in Marquardt's Test Division.

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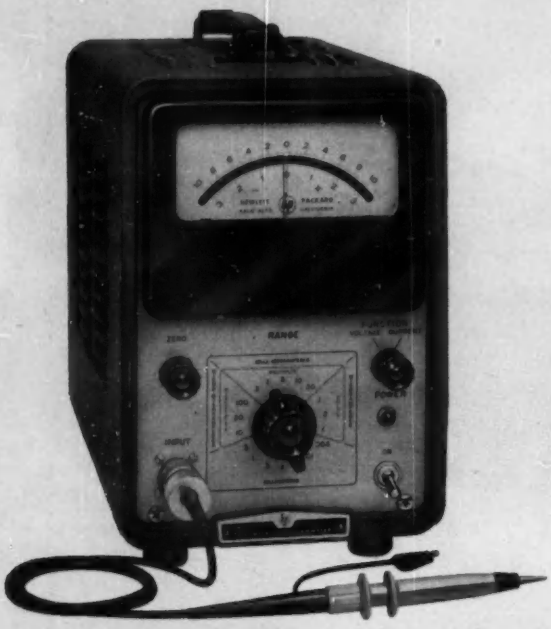
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THE GIST: In striving to meet the performance demands of high-speed aircraft, designers of hydraulic and pneumatic systems have found the normal "scale-up" problems to be compounded drastically by high-temperature effects. Indeed, the temperature levels are so high in some cases that much of the fund of hardware and techniques built up laboriously over the years must be abandoned. Crash research programs now under way are aimed toward relieving this situation by developing new bases for design. CONTROL ENGINEERING asked three men prominent in the fluid power field to state the problems involved and to report on the state of the art in the separate fields of hydraulics and pneumatics.

1. Future Aircraft Power Systems— Gas or Liquid?

GEORGE R. KELLER, Autonetics,
A Division of North American Aviation, Inc.



Advancements in flight propulsion techniques have raised, extremely rapidly, the speed and altitude capabilities of aircraft such as the X-15 manned missile (right). These major operational improvements have been accompanied by innumerable problems and complications that have demanded comparable advances across the whole broad front of flight technology. Nowhere has this demand been more evident than in the design of aircraft power systems.

For many years, hydraulics and, to a lesser degree, pneumatics have provided compactly packaged, reliable, responsive power to perform many aircraft tasks. Fluid power operates landing gear, actuates bomb-bay doors, drives radar dishes and steering gear. Perhaps the most important use of fluid power has been the operation of aerodynamic surfaces and controlling devices in both missiles and aircraft. In recent years, these and other applica-

tions of fluid power have been the subject of concentrated design effort made necessary by the addition of a new element—HEAT—to the customarily severe flight environment.

Aircraft operating at very high flight speeds within the atmospheric envelope of our earth develop high temperatures, which are caused largely by a shearing of the boundary-layer air. The temperature rise is a function of flight Mach number and is expressed approximately as:

$$T_{BL} = (1 + 0.18\ M^2)\ T_A$$

where: T_{BL} = boundary layer temperature, deg Rankin
T_A = ambient temperature, deg Rankin
M = Mach number

From the definition of Mach number, high speeds at low altitudes result in higher boundary-layer temperatures than the same speeds at high altitude. However, boundary-layer temperatures are not power system temperatures. If internal inefficiencies are ignored, the actual temperatures in the power system will be strongly affected by thermal capacitance and total heat. Thermal capacitance is the ability to absorb heat and is measured in Btu/deg F. Obviously, the larger the airframe and power system, the more heat can be absorbed before the temperature is raised appreciably. Total heat is a function both of the length of flight time at the high speed and of the boundary-layer temperatures caused by this speed.

These considerations suggest that:

1. High-speed winged vehicles pose major thermal problems.
2. Ballistic missiles or space vehicles encounter thermal difficulties primarily on re-entry into the atmosphere.
3. Large bombers will reach high system temperatures more slowly than small missiles.
4. Long-range, high-speed aircraft will experience more severe thermal effects than speedy craft having short flight times.

With some parameters of the problem established, how can the optimum power system be chosen? Hydraulic systems have had a long history of successful use at normal and moderate temperatures. For certain applications, pneumatic power, too, has been very satisfactory. Other power systems, including electrical types, have been avoided because of adverse torque-to-inertia ratios. The designers' task then is to attempt to adapt hydraulics and pneumatics to high temperature and, perhaps, to make a choice between them.

If 1,000 F were specified as the design temperature, the truth is that neither the hydraulic nor pneumatic systems known today could be made to function satisfactorily except over extremely limited times or usages. Fortunately, major engineering programs have been sponsored by the military to develop techniques for possible use at very high temperatures. In other articles, W. E. Mayhew, of Republic Aviation Corp., discusses work being done on hot hydraulics and C. H. Cannon, of Lockheed Aircraft Corp., describes the status in pneumatic control systems. An attempt will be made in this article to compare the two technologies and to predict what might be expected from these research programs.

Basis for choice

Hydraulics, of course, has the weight of experience behind it. Engineers are more familiar with the theoretical background and practical applicability of liquid systems than they are with the various aspects of gaseous systems. Familiarity alone, however, hardly justifies the choice of a power medium for tomorrow's weapons. Instead it must be assumed that each technique has problems which could be solved in comparable time periods. Each technique must be evaluated fairly, particularly in regard to questions such as the following:

1. What are the safety requirements imposed by the type of power system?
2. What are the handling problems?
3. Is the technique usable for all expected aircraft requirements?
4. Do problems of compatibility of materials exist?
5. What is the developmental status of components?

Although a design decision in favor of either approach—hydraulic or pneumatic—cannot easily be made on the basis of safety alone, it is nevertheless an important consideration. Because of relatively high bulk modulus, the energy content of a compressed liquid is low. Thus, the rupturing of a line or the loss of a fitting should not result in an explosive loss of the liquid. On the other hand, tremendous quantities of energy can be stored in compressed gases; and a structural failure in a pneumatic system could result in a large and destructive explosion. On the credit side of the safety ledger, proponents of pneumatic systems can claim absence of fire and toxicity hazards. In contrast, a break or leak in a high-temperature hydraulic system using an organic fluid would very probably result in a lively fire and possibly a secondary explosion. Also, the thermal breakdown products of some fluids are poisonous.

The relative importance of these hazards (explosion, fire, toxicity) will be determined only by continued work with both types of systems. However, it is already clearly evident that high-temperature power systems, no matter what fluid is used, must be treated with extreme caution.

Pneumatic techniques are free of many of the handling and storage problems that accompany high-temperature hydraulic systems. Extreme care is required in handling many good high-temperature liquids; the MIL-H-8446 silicate esters, for example, are susceptible to hydrolysis and demand special

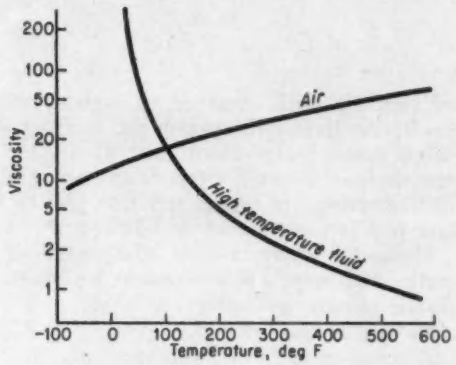


FIG. 1. Graphs compare the viscosity characteristics of air and fluid as temperatures increase.

packaging and treatment in the field if they are to be used successfully. Liquids tend to retain contaminants in suspension and will carry these contaminants to locations in the system where they can cause damage or faulty operation. Filtration, then, is a key element in hydraulic systems. Gaseous media must also be filtered; however, the large differences in the densities of the gas and of the usual contaminants ease the cleaning task.

Air used as a power medium poses no storage or leakage problems. Purchasing agents don't have to buy it, nor do truckers have to ship it. There are no inventory records to keep and Mother Nature rotates the stock quite efficiently so that a fresh supply is constantly available. Yet, air does have some drawbacks. Hoses, lines and fittings must always be in top condition to minimize leakage and prevent explosions. Lubricants and sealing compounds must be chosen carefully to exclude those that tend to oxidize rapidly. And the system must be kept free of moisture to minimize corrosion and avoid freezing during storage and down-time.

Viscosity factors

Low fluid viscosity, lubricity, and bulk modulus have been the primary reasons for the limited use of pneumatic systems in the past. However, there is indication that these disadvantages will be less objectionable for very-high-temperature power systems. The reason is that for air, each of the above characteristics remains essentially constant throughout the working temperature spectrum. In hydraulic fluids, on the other hand, these characteristics are very good in the normal temperature ranges, but deteriorate rapidly with increasing temperature.

Viscosity affects the ability of the fluid to leak past seals and determines pressure drop through orifices or chokes. The low viscosity of air at low temperatures can lead to leakage across high-pressure seals, a troublesome source of power loss. In addition, the accurate control of gaseous flows may require metering openings so small that they are not easily protected from clogging contaminants. At elevated temperatures, however, air has higher viscosity than most hydraulic fluids, Figure 1.

Despite its low value, the viscosity of air has one attribute that is regarded as spectacular in the light of today's flight environments: it is substantially constant over the whole thermal range. Over a given temperature band, for example, the viscosity of air may vary by a factor of only three while that of a typical high-temperature hydraulic fluid changes by a factor of 20,000. Thus, pneumatic systems are dynamically suited for wide variations in operating temperature. In contrast, hydraulic devices exhibit large changes in controllability stemming from the effects of fluctuating viscosity on the metering resistance of these devices.

The lack of lubricity in air requires special compounding of seals and careful choice of rubbing materials to avoid galling and seizure. At normal temperature levels, even the worst hydraulic fluids are superior to air in this respect. As operating temperatures rise, however, organic liquids become progressively poorer lubricants. And, the metallic fluids such as NaK_{77} needed for severe applications may have a lubricity characteristic that is actually lower than that of air. Therefore, in either hydraulic or pneumatic systems, the adequate lubrication of heavily loaded parts in moving contact will be difficult at high temperatures.

Many of the arguments favoring hydraulics over pneumatics rest on the low bulk modulus of gaseous systems. While not objectionable for some services such as landing-gear extension or bomb-bay operation, the low bulk modulus (or high compressibility) of air has restricted its use in primary control systems. The precision required in the positioning of large control surfaces demands that the fluid have a high effective bulk modulus to insure sufficient stiffness in the servomechanisms involved. The compressibility factor also limits the frequency response characteristics of pneumatic servo systems. In general, therefore, hydraulic systems have been preferred to pneumatic systems for inertial loads that must be positioned with great accuracy at high speeds. This should hold true for high-temperature operation as well.

The designers of pneumatic servomechanisms have developed many innovations that improve the stiffness of control systems. By employing artifices such as capacitance-resistance dampers and rate and acceleration feedback, ranges of controllability have been extended broadly. However, all of these techniques exact tolls in the form of lower reliability, increased bulk, higher weight, and other undesirable side effects. Hydraulic systems have many comparable problems. As temperature increases, the bulk modulus of organic fluids decreases. At very high operating temperatures, the positional stiffness of an hydraulic servo is but a fraction of its value at room temperature. Any tendency of the fluid to gasify, to boil, or to entrain air sharply reduces the effective bulk modulus of the working fluid.

The compressibility of gases imposes another

awkward design restriction. Because gas does work by expansion, the gas storage pressure must be greater than the working pressure. For example, in an effective 3,000-psi system, gas must be stored at pressures from 5,000 to 6,000 psi.

In general, the compressibility of gases will continue to pose a design problem for the control-system engineer. Nevertheless, pneumatics may be preferred for applications in which the loads are primarily spring-like (such as aerodynamic loads on a control surface) and the frequency-response requirements are not severe. Where loads are primarily inertial in nature and the dynamic requirements are strict, the hydraulic system will probably continue as first choice. Of course, these rigid criteria for selection do not apply to auxiliary services such as extensible landing gear.

Materials and component availability

The properties of materials at high temperatures have a bearing in the choice of fluid medium. Air and the other gaseous media used in pneumatic systems have no thermal or oxidative breakdown tendencies. On the other hand, organic fluids operating at high temperatures must be protected from water, air, and chemically active metals. It appears that 900 F will be the highest working temperature attainable by organic fluids. While much more heat resistant, the inorganic fluids such as NaK_{77} introduce problems in lubricity, pumpability, inflammability, toxicity, and tendency to contaminate.

Regardless of whether hydraulics or pneumatics is chosen, the metallic structural and dynamical elements will be a source of design headaches. Many metals suffer losses in both strength and modulus of elasticity with exposure to high temperature. Springs are limited by creep or the tendency to yield slowly under loaded conditions. In addition, high temperatures drive off certain gases that are adsorbed on the surfaces of metals and that play an important part in some aspects of lubricity.

Hydraulics enjoys a clear advantage over pneumatics with respect to component availability. Hydraulic pumps, servovalves, relief valves, and actuators have been developed for moderately high temperatures (up to 550 F) and are obtainable on the open market. Many design problems at even higher temperatures have received study and attention.

Until very recently, high-temperature pneumatic components were largely ignored. Although the work being performed by Lockheed is making up for this to some extent, the attention being given high-temperature pneumatic components continues to be much less than that directed toward high-temperature hydraulics. It can be expected, therefore, that in the range of 700 F, components for hydraulic systems will be available much sooner. Such may not necessarily be the case for 1,000 F, however.

The only certainty appears to be that much hard work needs yet to be done before very-high-temperature power systems of any form are a practical reality. As the technologies advance in the meanwhile, the system designer must weigh carefully the many factors involved in the application, handling, and fabrication of the power transmission system before an adequate choice of the working medium can be made. We are fortunate in having very fine developmental programs under way in both of the fluid power transmission fields. These will be described in the following articles.

2. *Hot Hydraulic Systems*

Since water boils at 212 F, rubber-like materials deteriorate at 400 F, and steels glow red at 900 F, what are the possibilities of designing an hydraulic flight control system to operate in the region of 1,000 F?

WILLIAM E. MAYHEW
Republic Aviation Corp.

Hydraulic system temperatures in today's high-speed aircraft are no higher than 275 F—with one exception: where fluid temperatures are allowed to reach 350 F. Tomorrow's aircraft systems (now on the drawing boards) will operate in the minus 65 to plus 400 F temperature range, and on up to 550 and 700 F temperatures. And, the hydraulic flight control systems of future airborne and space vehicles will certainly begin to approach 1,000 F.

It would be desirable, of course, if the hydraulic designer could meet the temperature requirements outlined by resorting to upgraded versions of conventional fluids, variable-delivery piston-type pumps, airless reservoirs, filters, relief valves, tube fittings, servovalves, and actuators. Unfortunately, however, the present state of the art in hydraulic fluids and components will not permit the designer to go safely beyond 400 F. The gambler may be willing to design for 550 and possibly 700 F for short periods of operation, but, more often than not, the dependability of the system will be seriously limited by the fluid. The following discussions will outline what is being done to raise the temperature limits on fluids and system components.

Fluids

There are two fluids capable of continuous operation in the minus 65 to plus 400 F range; namely, a disiloxane-base fluid (ORONITE 8515) and a sili-

cate ester-base fluid (OS-45-Type IV). Limited operation beyond 400 and up to 550 F is also considered possible for both. These fluids have been extensively tested and ORONITE 8515 is in service in a current supersonic bomber. Other chemical compositions considered for this range were diesters, petroleum-base fluids, and silicones. Diesters were disqualified primarily because of low-temperature viscosity properties, marginal thermal stability, and sludge formation. Petroleum-based fluids were unacceptable because of excessive vapor pressures between 300 and 400 F, and because of marginal lubricity at 400 F. Silicones were rejected because of compressibility, poor lubricity, and a lack of response to additives.

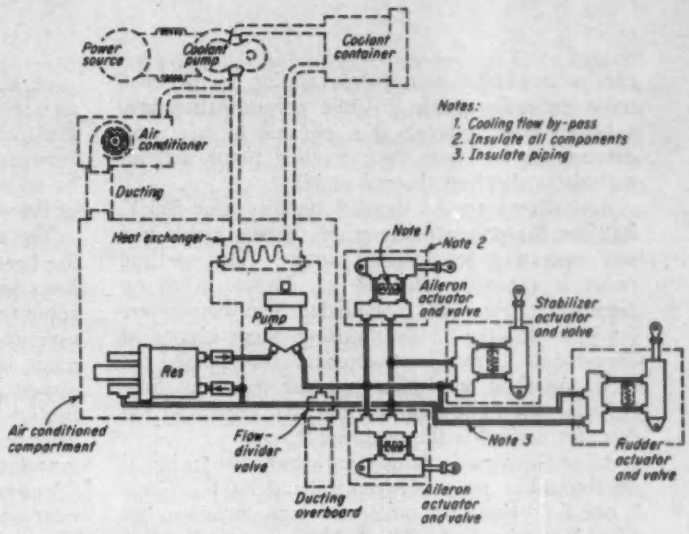


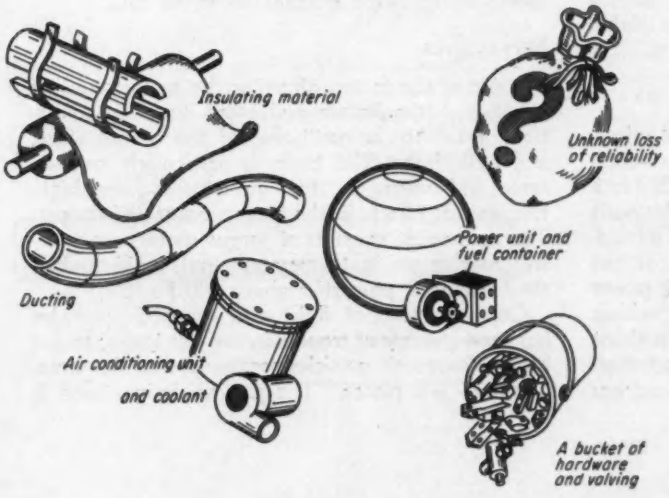
FIG. 2. Conventional flight control system designed to operate at 1,000 F, but using 400 or 700 F fluids. Dotted lines indicate cooling support equipment.

In the minus 65 to plus 700 F range, the silicones have received the greatest attention. A chlorophenylmethyl fluid (GE 81406) for example, has excellent viscosity vs. temperature characteristics and better lubricity than most silicones, but is deficient in thermal stability, oxidative stability, foaming, and bulk modulus. Two additives, iron octoate and stannic chloride, have shown promise in improving the oxidation-corrosion stability of 81406. Stannic chloride increases lubricity as well.

Also being investigated for 700 F operation are the alkyl silanes, mineral oils, and esters. Although the alkyl silanes exhibit the best thermal stability, vapor pressures are much higher than in the other two types. Of the three, the silanes are the most recently developed fluids; consequently, their overall capabilities are still under evaluation. Two alkyl silane compounds under study contain additives that improve the viscosity index, lubricity, and oxidation-corrosion resistance. The mineral oils and esters are superior to the silanes in regard to lubricity. The mineral oils show less corrosive tendencies and more resistance to oxidative deterioration in the presence of metals than do the esters at 700 F. Tests indicate no adverse wear effects in mineral oils at temperatures up to 600 F and a naphthenic-type oil formed no solids after several hours at 750 F. However, partial decomposition does take place at 700 F, as evidenced by a decrease in viscosity.

Figure 2 shows a conventional flight control system designed to operate at 1,000 F, but employing 400 or 700 F fluid. The severe handicaps imposed on the aircraft by cooling this system to keep fluid temperatures within safe, operational limits are dramatically illustrated in Figure 3. Weight, space, complexity, reliability, and maintenance requirements are all affected adversely. The penalties are least where the aircraft's fuel can be used as a heat sink and a 700 F fluid is employed; conditions are especially bad when it is necessary to cool from 1,000 to 400 F, and some cooling medium other than the aircraft fuel must be carried in the aircraft.

FIG. 3. The penalties that must be paid for using low-temperature system in a high temperature environment.



In tests by the General Electric Co., the silphenylenes show promise for 800 F operation and beyond, but suffer from lack of lubricity, which is characteristic of the silicone family. Other thermally stable fluids in the 800 F range are the polyaromatic ethers, polyaromatics, aryl silanes, and organo-metallics. Limited tests of these fluids indicate the possibility of operation near 1,000 F. The polyaromatic ethers seem suited for 800 to 860 F and

the polyaromatic compounds appear to be even more thermally stable. While polyaromatics have a higher melting point, it is possible to mix these compounds to lower their melting point without materially affecting thermal stability.

Aryl silanes possess thermal stability near 800 F, but like the polyaromatic ethers, have a rather narrow operating temperature range. The melting point is approximately 148 F. Present work on organo-metallics and metalloidal high-temperature fluids is devoted to synthesizing these classes of compounds. From a theoretical standpoint, the metal-to-carbon bond offers superior strengths. Synthesizing the right combinations that impart all the qualities desired is the problem at hand.

All of the organic fluids mentioned have an initial decomposition point between 800 and 900 F. There is one fluid that does meet, and even surpasses, the 1,000 F requirement. This is NaK_{77}, a eutectic alloy consisting of 23 percent sodium (Na) and 77 percent potassium (K) by weight. NaK_{77} is one of the few liquid metals or metal alloys that are liquid below plus 100 F and have boiling points over 1,000 F. It possesses some very distinct advantages: an operating range of plus 10 to 1,443 F, low vapor pressure, high bulk modulus (five times greater than an organic fluid at elevated temperatures), good nuclear radiation resistance, low cost, and wide availability.

NaK_{77} is corrosive to more metals than are affected by organic fluids. This property is critical because the number of usable metals is already restricted by high temperatures. The lubricity of NaK_{77} is practically nil and up to the present time no methods have been found to improve it. Certain metals tend to self-weld in NaK_{77}. Metal transfer is troublesome; for example, a material may partially dissolve in NaK_{77} and plate onto a dissimilar metal in an isothermal system, or onto a similar metal in a colder region. The consequences of either of the above two phenomena at a pump, servovalve, or other sensitive component, would make the system inoperative. The ground handling of NaK_{77} demands the use of protective clothing, including hooded face masks with self-contained breathing apparatus. Work and storage areas must be designed to prevent fire or explosion, because NaK_{77} reacts violently with water to form hydrogen.

Components

Although components such as filters, relief valves, check valves, tube fittings, and quick disconnects cannot yet be taken off the shelf and installed in a high-temperature vehicle, their refinement for such services does not involve design problems as formidable as those for the pump and servovalve. It can be expected that a hydraulic pump supplying power to surface control actuators in an advanced air vehicle will be subjected to temperatures ranging from about 700 to 750 F. When tied in with high pump-shaft speeds and high pressures, even these temperatures pose a pump-design problem of considerable magnitude, associated with seals and bearings especially. Elastomeric seals appear to be of marginal worth between 700 and 750 F and will probably be replaced by seals of materials such as metal, graphite, carbon, or the new du Pont fluorinated hydrocarbon material.

The ideal bearing material for applications involving heat, corrosion, and lack of lubrication has not been found as yet, although the cobalt-base alloys come very close because of good resistance to corrosion under oxidizing conditions and the ability to retain hardness in the red-heat range. These alloys possess good wear resistance and low coefficients of friction, indicating a capability of operating with little or no lubrication. Because little help can be expected from the fluid in the way of lubricity, consideration must be given to materials having suitable wear and gall resistance. The close fits between pistons and bores required in current piston-type pumps for high pressures and maximum efficiency call for materials with good wear and gall resistance and for material combinations having similar and low coefficients of thermal expansion.

The pump prime mover will be a high-speed device, such as a gas or ram air turbine, necessitating a gear box to reduce pump-shaft speeds. For weight, space, and reliability considerations, it would be highly desirable to eliminate the gear box and drive the pump at turbine-shaft speeds. This arrangement would eliminate the gear box and reduce the weight and volume of the pump itself. It is claimed that a centrifugal pump can be directly coupled to a turbine drive, is relatively insensitive to small clearance changes or dimensional variations, and is more reliable than a piston-type pump because of the fewer number of moving parts. However, the regulation of discharge is more of a problem and efficiency depends on large flow capacities and high shaft speeds. Discharge pressure can be regulated by use of a pressure unloading valve and accumulator; however, this additional equipment adds complication and offsets the simplicity advantage of the pump proper. The efficiency of the centrifugal pump is estimated at 60 to 65 percent for shaft speeds in the range of 35,000 to 45,000 rpm.

Servovalves

Some of the factors affecting the performance of an electrohydraulic servovalve are fluid contamination, instability or oscillation of the output stage, and null shift. The latter is particularly troublesome and seems to stem principally from high-temperature effects in the torque motor and flapper. The permanent magnets of torque motors are sensitive to changes in temperature and begin to lose their magnetic properties above 500 F.

Contamination of fluid with magnetic particles has been a source of trouble in the wet torque motor because magnetic particles accumulate on the armature and pole pieces. The present design trend is

towards the use of the dry torque motor, in which the flapper is generally fastened to a diaphragm that seals the torque-motor chamber from the drain oil. A temperature differential on either side of the flapper, however, will cause flapper movement and contribute to shifting of the null position.

As temperatures increase beyond today's "high" temperatures, the decreasing value of the bulk modulus of the hydraulic fluid has a severe effect on the problems discussed briefly above. A new type of servovalve, the acceleration switching valve, has indicated a capability of coping with the high-temperature problems. The valve is basically an on-off, two-stage servo. The torque motor is essentially a single coil switch, which moves a conventional nozzle flapper. The flapper alternately covers and uncovers the two orifices, one for a longer period of time than the other, to effect a linear curve of flow vs. differential input current.

Some advantages claimed for the first stage of the acceleration switching valve are that permanent magnets are not required and variations in nozzle gap spacing as a result of temperature do not adversely affect dynamic performance and null shift. Because there are no springs in the second stage, the problem of variations in spring rates with temperature is eliminated. In addition, spool motion is continuous because of the built-in dither feature, so that the valve is relatively insensitive to unequal static friction and fluid contamination, which might cause jamming of spool and sleeve. The time lag of the torque motor does not affect the performance of the valve. Therefore, the dynamic capabilities should be better than the conventional proportional servovalve. Disadvantages include increased complexity of the electronic system and the continuous dither, which in turn could increase wear of the spool and sleeve.

The prospect of finding materials suitable for sealing and maintaining close sliding fits in high-temperature pumps and servovalves is encouraging in many respects. The material properties needed for these applications are wear and gall resistance, high-temperature oxidation resistance, hot hardness, and adequate strength on exposure to high temperatures.

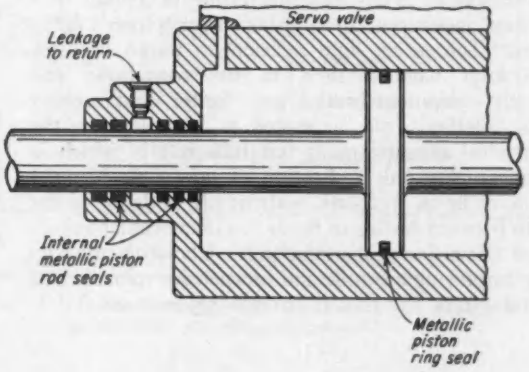
Cobalt-base alloys such as Haynes No. 99, N153, S-816, and Jetalloy 1570 possess desirable properties for pump and valve applications. At 1,200 F, most of the iron-base alloys, including 19-9 and Incoloy, tend to have oxidation problems. The strength and hardness properties of these alloys deteriorates from room-temperature value to a point where strength-weight ratio compares unfavorably with the nickel and cobalt-base alloys.

Cermets and ceramics have good high-temperature and oxidation-resistance characteristics but possess an inherent notch sensitivity and poor impact strength. Their greatest use will probably be in the form of coatings to be used on existing materials which are not by themselves suitable for high temperatures. A typical cermet is titanium carbide plus nickel, chromium, and cobalt. Surface treatments and coatings have been investigated in an attempt to overcome the seizing and galling, excessive wear, and friction tendencies of some high-temperature alloys. Tests indicate that "electrolizing" one of the two similar moving surfaces decreases the tendency of the materials to wear and gall excessively and imparts corrosion resistance and an extremely low coefficient of friction. An Inconel-X material, given a Linde LA-2 aluminum-oxide flame-plating treatment and run against a Haynes Alloy No. 25 load block, demonstrated superior wear and gall resistance in a 1,000 F environment.

Seals

The hydraulic seal problem manifests itself primarily in dynamic applications such as a flight control actuator, wherein the rod seal is subjected to continuous maximum system temperatures and to high-amplitude/low-frequency and low-amplitude/high-frequency cycling at various times during flight. Up to the present time, dynamic seal configurations have usually consisted of an elastomeric O-ring supported by back-up rings for 3,000-psi pressures, for operation in the minus 65 to plus 160 F range. When the 160 F upper limit for MIL-0-5606 fluid

FIG. 4. Two-stage seals for piston rod of hydraulic actuator.



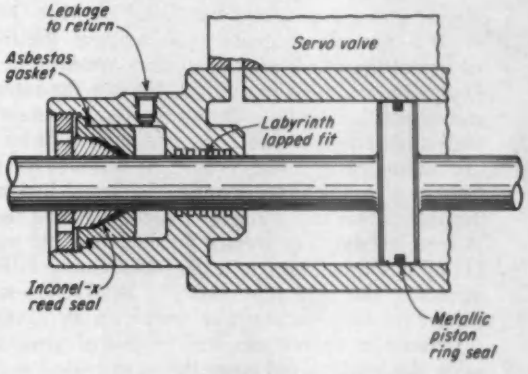


FIG. 5. Another form of two-stage seal for an actuator rod—the most critical sealing point in an aircraft control system.

was recently extended to 275 F, the standard elastomeric O-rings were recompounded to withstand the higher temperature. The solution to sealing a closed system using MIL-0-5606 fluid at 275 F was not obtained easily or quickly; in fact, it is still questionable whether a completely effective seal exists.

New synthetic seal compounds formulated for the minus 65 to plus 400 F range have been tested extensively over the past several years. This testing can not be fully correlated and evaluated, however, since test methods and conditions were not consistent. The increase in hydraulic system temperatures beyond 400 F makes the possibility of utilizing elastomerics questionable. However, the test of a du Pont fluorinated hydrocarbon material resulted in high-temperature performance heretofore considered impossible for an elastomeric compound.

Republic Aviation conducted a series of high-temperature, high-pressure tests on rod seals of this Viton A material. A ceramic and molydisulphide-impregnated teflon material made by the Rogers Corp. backed up the seal. Leakage did not occur until after one-quarter million 4-in. strokes under pressures ranging from 0 to 3,000 psi and temperatures cycled between 0 and 450 F. One-half million short-stroke ($\frac{1}{8}$-in.) cycles were obtained from a modified Viton A material under the same temperature, pressure, and fluid conditions. Additional proof that elastomeric compounds should not be ruled out completely above 400 F is borne out by some recent tests at Republic in which a silicone fluid (GE 81406) was used in lieu of the Monsanto silicate-ester fluid (OS-45-IV) to achieve higher fluid temperatures. Under 0 to 3,000 psi and fluid temperature of 680 F, 134,000 short-stroke ($\frac{1}{8}$-in.) cycles were obtained.

Metallic seals have been tested by several manufacturers in recent years, notably the Autonetics Div. of North American Aviation and Boeing Airplane. Both static and dynamic seals were involved. Since there is no motion of the mating parts, static sealing is easier to accomplish. Metallic static seals offer promise for 1,000 F operation and are of various configurations, such as the metallic O-ring, which can be sealed with atmospheric pressure inside the ring or with a pressurized inert gas. Another O-ring shape is the self-energizing type, wherein the inner surface of the ring is pierced to allow system pressure to penetrate inside the ring and balance the internal and external pressure. O-ring seals are of stainless steel and require a relatively fine surface finish on the mating parts. The Skinner or bellows-type seal seals by a combination of spring force and hydraulic pressure. This seal is made of Inconel X and seems to require even finer surface finishes than the metal O-ring. Other static metallic seal configurations, including the reed type and the WADC metallic boss, have been successfully tested up to 1,000 F.

Because its failure can lead to loss of plane and pilot, the actuator rod poses the most critical sealing problem in a high-temperature control system. A dynamic seal for this application must meet rigid requirements such as essentially zero leakage and minimum friction and misalignment under varying conditions of pressure, temperature, and cycling rates. A possible approach to the problem, Figures 4 and 5, is a two-stage seal, wherein the first seal is subjected to system operating pressure while the second seal is subjected to return line pressures. A port between the two returns leakage flow to the reservoir from the high-pressure seal. The high-pressure seal in this design is always lubricated by the fluid and if leakage does occur it will be gradual. The second-stage seal is not subjected to both high pressures and high temperatures simultaneously and, therefore, should be effective a longer period of time.

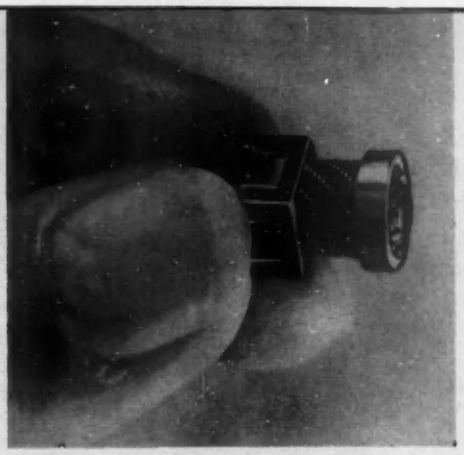
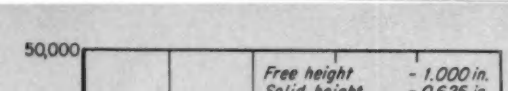


FIG. 6. Miniature hydraulic filter for high-temperature aircraft systems designed for temperature range from minus 90 to plus 700 F. (Purolator Products, Inc.)

Summary and recommendations

The search for an hydraulic fluid to operate in the 800 to 1,000 F range must be intensified if the hydraulic systems needs of advanced vehicles are to be met. The immediate goal should be to increase the fluid-operating temperatures, especially for short-term high-temperature operation, in order to provide the lightest, simplest, and most reliable system possible. Without a fluid possessing suitable properties of thermal stability, lubricity, viscosity, bulk modulus, the airframe manufacturer faces formidable problems in systems design, analysis, and testing under simulated service conditions.

There appears to be a serious gap between the initial testing and determination of the physical properties of fluids and the testing of a fluid in a system mockup at an airframe manufacturer's facilities. Too often, fluid deficiencies found in these mockups have resulted in time-consuming and costly equipment breakdown. Better fluid-property test methods are necessary to complement the chemical manufacturer's test tube results, which in essence give only indication of how a fluid might behave in an hydraulic system. A bridging of the gap between testing of fluids in a chemical laboratory and the airframe manufacturer's laboratory mockup by employing a simple and inexpensive miniaturized fluid-system test unit is strongly recommended.



Reliability will be of paramount importance in future aircraft, missile, and space vehicles where, in many cases, no other means are provided for aircraft control. A design goal of simplicity and a minimum number of components should be strived for, even at the expense of weight and space. Endurance testing should be increased and testing under more realistic and complete system conditions is required. Because leakage is a dominant factor in overall system reliability, systems and components should be designed for a minimum of joints.

The outlook for hydraulic systems to perform satisfactorily and reliably in future advanced aircraft is encouraging. A number of significant advances have been made in the hydraulics industry which surpass by far, advances made in other segments of the aircraft industry. The building materials that hydraulics engineers require are available. How soon the ultimate goal can be realized is dependent on the time and effort exerted by the military, airframe, and equipment manufacturers to learn how to use these building materials.

3. Hot Pneumatic Systems

The 1,000 F pneumatic system is near reality. Although the problem of finding a good dynamic seal still remains, researchers have been able to come up with acceptable high-temperature versions of most of the needed components, and refinement is under way.

C. H. CANNON
Lockheed Aircraft Corp., Georgia Div.

There are strong indications at present that the 1,000 F pneumatic system is not only feasible but will outperform any hydraulic system now conceivable for operation at an equivalent temperature level. This tends to promise wide application of pneumatic controls in aircraft and missiles designed for speeds between Mach 3.5 and 5.3 and for altitudes from 40,000 to 80,000 ft. These are the boundaries wherein the 1,000 F environment is expected.

It is possible further that the problems in developing high-temperature hydraulic systems will be of such magnitude that it will be desirable to lower the 1,000 F temperature criterion for pneumatic-system use to 700 F. Even for current aircraft, in fact, the inability of hydraulic components to withstand high temperatures, plus the decay in the bulk modulus of hydraulic fluids under heat, has made cooling necessary. The Convair B-58 bomber, for example, employs heat exchangers to lower fluid temperatures to a normal 350 F. And the new North American Chemical Bomber, the B-70, will probably require heat enchangers to keep system temperatures below 450 to 500 F.

The prime manufacturers of missiles, air frames, power plants, and nuclear reactors have displayed increased interest in pneumatic control systems. One company, for example, is studying pneumatic control for jetevators on a new missile. The hydraulic system presently used for this purpose includes batteries, an electrically-driven hydraulic pump, a reservoir, and an accumulator above the transmission lines. In a pneumatic system, all of this equipment could be replaced by a single storage bottle; in addition, the return lines would be eliminated. The prime benefit expected is a considerable saving in weight, a tremendously important factor in missile design, especially in the final stage, where each extra

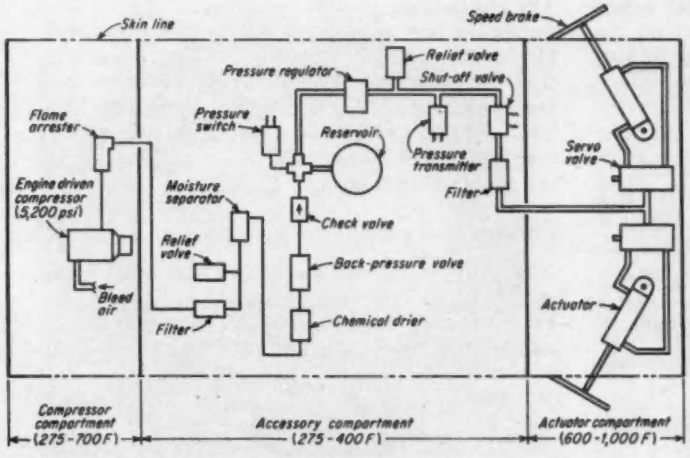


FIG. 7. Schematic diagram of speed-brake system showing compartmentation and temperature ranges.

FIG. 8. View of disassembled 1,000 F pneumatic actuator shows parts for cylinder (left) and piston rod.



The sleeve on the fittings also was of Inconel-X and were used for the end gland, Figure 11, and for the

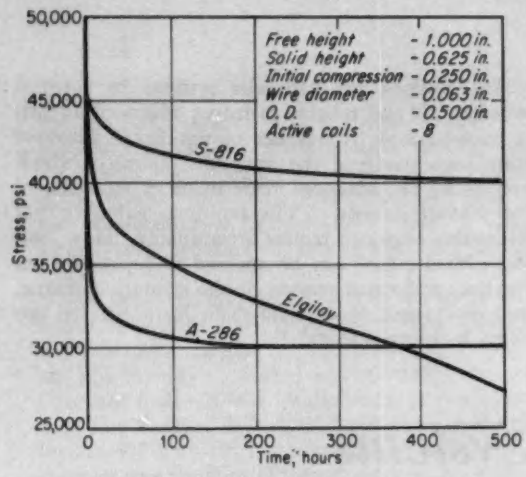


FIG. 9. Curves show relaxation tendencies of new spring materials at 1,000 F.

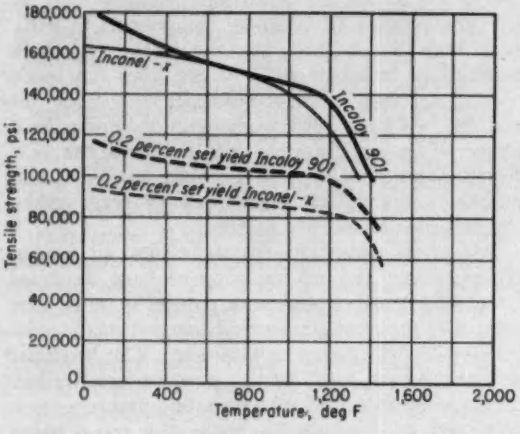


FIG. 10. Tensile strength of Incoloy 901 and Inconel-X remains high up to 1,200 F.

pound must be supported by a great amount of additional weight in the initial stage.

Another immediate use for the 1,000 F pneumatic system is for the tail-pipe actuator on high-thrust jet engines. Temperatures in the tail region have increased considerably and will probably be stepped up still further in the next family of higher-Mach-number weapon systems.

High-temperature design problems

Since May 1956, Lockheed has been working on an Air Force contract to develop a servovalve and actuator to operate at 1,000 F, 5,000 psi. Figure 7 is a schematic of the overall system, which is to operate a speed brake, and Figure 8 is a photograph of the actuator developed for the purpose. Some of the phenomena that hindered the development of the 1,000 F components are as follows:

1. Physical strengths of metals known today decrease with increase in temperature
2. The common spring materials relax at increased temperatures
3. Thermal effects cause changes in the dimensions of parts
4. Rubbers, plastics, teflon, and synthetics deteriorate
5. Wet lubricants and presently available greases do not stand up
6. Lack of lubricity causes high friction and tends to produce galling and seizure of moving parts
7. Threaded units may seize and weld tight

To successfully overcome these difficulties, new materials and techniques are obviously necessary. The high-temperature pneumatic system that has operated satisfactorily at 1,000 F incorporates the following innovations:

1. Metal parts of new super alloys
2. New spring materials, Figure 9
3. Close dimensional control despite thermal effects by selection of materials having similar coefficients of expansion and by careful specification of necessary clearances
4. Elimination of seals of synthetics, plastics, etc.
5. Solid-film and graphite lubricants
6. Special processes and plating to reduce friction and prevent binding or galling

The search for high-temperature metals led to the engine manufacturers. Present turbine engines operate in the 1,000 F region, although there is no metal-to-metal contact in the hot sections of these engines. Because sufficient clearances are used to make galling or seizing impossible, engine materials need not have good wear properties. On the other hand, many tool steels have good strength at elevated temperature but poor corrosion resistance.

The materials that exhibited the best overall characteristics were the Stellites and Inconels, Figure 10. Wear tests confirmed earlier reports of immediate galling when parts of age-hardened Inconel-X were run together or when Inconel-X was run in contact with hardened steel. This spurred an immediate search for suitable surface treatments.

Linde LA-2 aluminum-oxide flame plating was found to have superior wear and galling resistance. The electrolizing process also provided a good wear surface for use against LA-2 flame-plated material. Haynes Alloy No. 25 has excellent wear characteristics. Tests on many other materials revealed several fair combinations. Of the dry film lubricants, Electrofilm 2006, Everlube and Metal Matrix proved the best. The latter two, however, were more susceptible to scaling.

Fittings and seals

Tests of fittings were made on a manifold accommodating eight different combinations at one time. The tests were concentrated on Inconel-X tubing and fittings (both MS and AN type). Threads were treated with silver plate, electrolizing, or dry-film lubricants. After the required exposure at 1,000 F, the fittings were easily removed from the manifold. No galling or deterioration was evident.

The sleeve on the fittings also was of Inconel-X and was electrolized to increase the hardness sufficiently for the sleeve to take a deeper bite into the tubing.

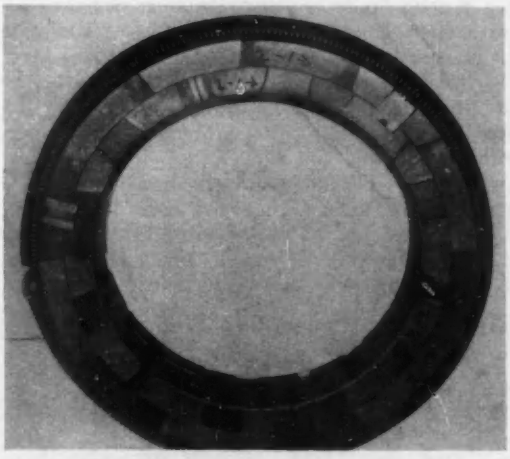
Various static seals of Inconel-X, including the WADC boss, Autonetics, Skinner Spring, and Fulton Sylphon V-face types have been evaluated on the same manifold. Yet to be tested are Krueger seals supplied by Harrison Mfg. Co. and three metal O-rings made by United Aircraft Products, Advanced Products, and DSD Mfg. Co. All four seals were termed satisfactory for 1,000 F, 5,000 psi, and permitted only extremely small amounts of leakage (ranging from 0 to 80 cc per min). In several installations, the WADC boss seal and the Autonetics seal allowed absolutely no leakage and were felt to be the best tested. In general, metal O-rings are not desirable because tight sealing is difficult and very large torques are necesary to seat them.

Actuator

Enough component parts have been fabricated to allow assembly of four complete actuator assemblies. Each assembly is identical in basic appearance, but contains various types of seals. The actuator has a 4.00-in.-diameter bore, 2.00-in.-diameter piston rod, and 10.80-in. stroke. Axial thrust is 40,000 lb at 3,600 psi. The basic structural material is Inconel-X, which has good wear resistance, is easy to machine, and has high resistance to creep. The material is received from the mill in the hot-finished condition. After rough machining, it is given a high-temperature equalizing treatment of 1,625 F for 24 hours, followed by furnace cooling. The purpose of this treatment is to maintain small grain size. Subsequent age-hardening for 20 hours at 1,300 F yields maximum strength for temperatures up to 1,100 F.

The first of the four cylinders, consisting of an Inconel-X barrel with a pressed-in Haynes Alloy No. 6B liner, has been evaluated. The inside diameter of the liner was machined to a beautiful mirror-like 2-rms finish. Koppers carbon-type seals were used for the end gland, Figure 11, and for the piston rod. The break-away friction of the assembled actuator was only 8 lb, a surprisingly low value considering the 4-in. diameter of the piston and the 2-in. diameter of the piston rod. When air pressure was applied to this actuator there was some leakage by the end seal, probably because the Koppers seals are made up of segments (nine in the case of the end gland and 18 for the 4-in. piston head). Its extremely low density and high pressure enables the air to find its way through these minute passages. It was found, however, that a carbon-type seal on a rotary plate valve produced a tight seal.

FIG. 11. High-temperature seal made of carbon segments.



As evidence of the importance of a tight seal, it has been found that 0.001-in. diametrical clearance in a 4-in. diameter piston will allow 50 lb per min leakage at 4,000 psi. Leakage past the piston seal can be tolerated; however, any leakage by the end gland is detrimental.

A Cumpac seal, Figure 12, was tried next and was found to leak excessively on the first pressure check. Investigation revealed that the bolts compressing the seal assembly were not torqued to high enough values. When this condition was corrected, leakage was decreased. The piston break-away friction with this seal was about 40 lb. Further testing is under way; it is still too early to predict what the most satisfactory seal configuration will prove to be. The actuator bearings are plain spherical type designed by Kahr Bearing Co. of Burbank, Calif. The race is of the GE J-1570 alloy and is silver plated on the inside diameter. The balls are J-1570 also and are electrolized.

Valves

Current tests on servovalves appear to favor the use of the Lockheed spool-type valve. Although the leakage in the interim versions of this valve has been higher than the allowable value up to now, the valve is operational. A rotary plate valve, designed at Lockheed expressly for decreased leakage, has also been tested. Two test units have been fabricated by Cadillac Gage Co., Detroit. This valve consists of three basic assemblies: a Koppers rod seal assembly and housing that features pressure-loaded segmented rings of a carbon-graphite compact, a base, and a rotor, Figure 13. The supply pressure and cylinder lines have two orifices each at the surface of the base, which mates with the optically flat surface of the rotor. One orifice in each pair is diametrically opposite the other orifice of that pair, and they are equidistant from the center. This arrangement is designed to facilitate the static force balance.

When the valve is in the neutral position, the cylinder orifices in the base are completely blocked by the face of the rotor. Their position is exactly halfway between the runout points of metering grooves machined into the rotor face. Turning the rotor in either direction gradually uncovers the

cylinder ports; pressure is metered to one chamber and exhausted from the other through the rotor shaft. The increase in metering area is proportional to the square of the angular displacement of the rotor from neutral. For full rotor travel (18 deg) the metering area is 0.030 sq in.

The efficiency of the metering action described depends completely on the maintenance of intimate contact between the optically flat mating surfaces of the base and rotor. The pie-shaped portions removed from each side of the rotor face insure that the pressure orifices in the base will be uncovered for all rotor positions. Clearance between the rotor outside diameter and the seal housing permits pressurization of the upper side of the rotor also. The contact between base and rotor will be maintained, theoretically, because the area exposed to system pressure on the upper side of the rotor is greater than that similarly exposed on the lower side.

The rotor and base must be preloaded against one another by some means other than system pressure. Otherwise, a sudden application of pressure could force air through the contact area between rotor and base. Positive preloading is assured by a three-wave washer between the upper surface of the rotor and the seal housing. This washer is made of 0.018 in. Inconel-X and has a free height of 0.100 in. When installed, it is compressed approximately one-fourth of this amount. The spring constant is such that the preload on the rotor is about 12 lb.

The area of rotor face in contact with the base is about 0.054 sq in. greater than the shaft area. In a 4,000-psi system, therefore, there is a force of 216 lb holding rotor and base together. The principle of two optically flat surfaces held together by system pressure is not new; many hydraulic valve designs are based on it. However, as far as is known, the principle has not been employed previously in the design of high-pressure pneumatic components.

The torque required to overcome friction between the rotor and seal and the two mating faces adversely affects servo-system characteristics. To minimize friction, several steps are taken. Haynes alloy No. 25 is specified for the rotor and Inconel-X for the base. The mating surface of the base and the area of the rotor shaft in contact with the shaft seal are flame-plated with aluminum oxide.

Because the base is optically flat (machined to one sodium-light wavelength) and because the rotor is pressure-loaded to control proper seating on the base, the rotary valve was thought to be leakproof. However, the low densities and high pressures involved allows air to push its way between the two surfaces and to force the rotor off the base. This valve, therefore, is being redesigned to provide more positive loading of the rotor on the base in order to insure seating and prevent leakage. It is expected that this difficulty will be solved as was the problem of preventing break-out or chipping of the flame plating at the edges of the valve base.

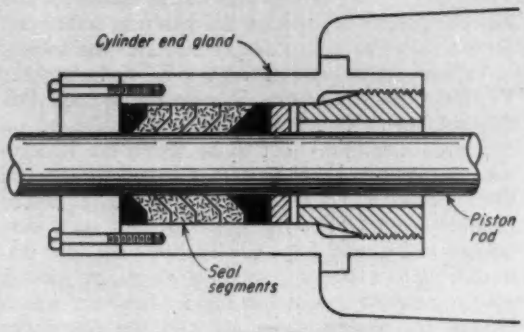


FIG. 12. Cumpac seal for end gland includes segments of molded asbestos, Inconel-X mesh, and graphite-impregnated material.

Spool valves

In designing spool valves, it is vital to keep the diameter as small as possible because the leakage tendencies are directly related to diameter. However, in small-diameter (¼-in.) spools the fineness ratio (L/D) becomes high. This makes it difficult to maintain straightness, an essential characteristic if leakage and binding are to be avoided. Designs of new spool valves with spools of minimum length are profiting from tests already conducted. Some of the known design criteria are:

1. Valve leakage increases directly with increase in spool diameter
2. Spool fineness ratio should be as small as possible to prevent warpage and binding and to insure straightness in manufacture
3. Diametrical clearances down to 50 millionths of an inch are necessary to keep air leakage low
4. All parts should be made of the same material so that they will have identical coefficients of expansion

The most promising servovalve so far is a so-called rotary-spool type. In this valve, a spool with a fineness ratio of 1:1 is rotated within a sleeve. Unlike the rotary-plate valve, where metering takes place between two flat surfaces, the rotary-spool valve meters through orifices on the spool periphery. A small diameter is not required because leakage is a function only of orifice size and clearance between the spool and sleeve. Very close fits may be maintained between spool and sleeve without binding problems since the fineness ratio is unity. In addition, the spool rotates instead of sliding in the sleeve, so that lower operating forces are noted even with a tight fit.

One other unit under investigation is a poppet-type metering valve. This valve poses many problems in metering and is not inherently suited for servo use. However, it has practically zero leakage, and for this reason studies are being continued.

Servo stability

A modified C-130 booster control and the speed-brake valve and actuator have been operated sufficiently long to provide meaningful data on stability. Information obtained on the C-130 pneu-

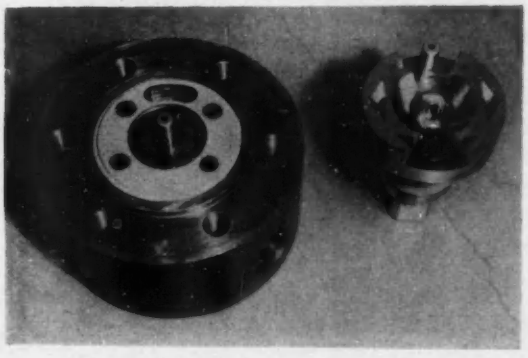
matic servo indicated stability with output mass of 1.20 lb-sec²/in. at frequencies up to 5 cps. The speed-brake servo has a large output mass; calculations indicate that this system is liable to chatter in a frequency range between 26 and 120 cps, depending on door position.

There are two methods by which that chatter problem can be overcome. One is the addition of accumulator chambers between the valve and cylinder to provide damping. The presence of these chambers (properly sized) and flow resistance introduce a stabilizing transient flow to each line when cylinder pressures are changing rapidly. The value of this approach has been confirmed by tests on the speed brake and the modified C-130 booster.

A second measure used successfully for stabilizing the speed brake is velocity feedback. This concept has proven itself for stable speed-brake operation under loaded and unloaded conditions and is actually the preferred approach at present. The effectiveness of velocity feedback in this case is obvious when it is considered that the speed-brake control is actually a simple servo system; the output or actual position of the speed brake is continuously compared to the input or desired position. If a completely incompressible fluid were used, the actuator would stop instantaneously when the valve closed, indicating the output was at the desired point.

In reality, inertia tends to carry the output past the desired point and, because the fluid is compressible, the build-up of the force necessary to stop the mass of the system requires a finite time. Stability is easily attained if the velocity and momentum of the output is low. However, when a high velocity is required, some equalizing or stabilizing factor must be introduced. In rate-feedback servos, the control device (the valve in this case) responds to the sum of the actual position error plus a displacement that is proportional to the output rate or velocity. Thus, if the actuator approaches the desired position at any significant velocity, the valve will close (and even reverse) before the error is zero. The reverse or braking force is thereby applied in sufficient time to stop the speed-brake door at the desired position. The components in the rate-feedback portion of the system are essentially linear. Therefore, the valve is closed sooner with higher velocities and later with lower velocities, tending to produce the required stabilization regardless of the value of the velocity.

FIG. 13. Rotor and base for rotary-plate servovalve.



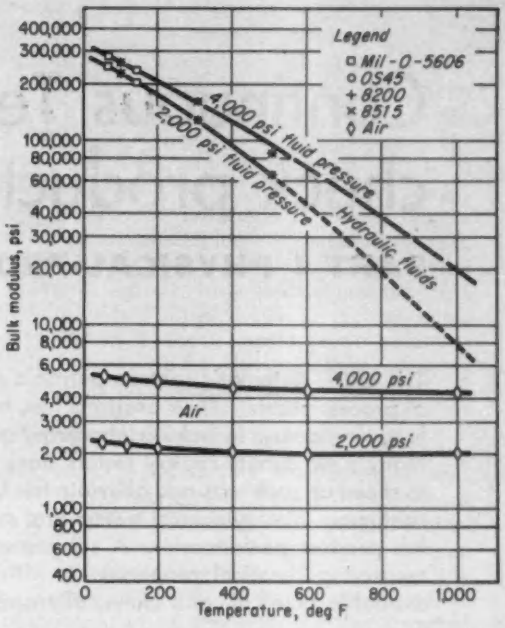
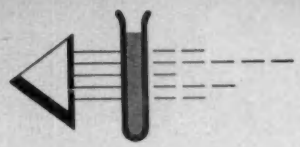


FIG. 14. Chart of bulk modulus vs. temperature for various fluids.

Safety

The 5,000-psi pneumatic system demands respect; in fact, for safety reasons tests are conducted in a block-house-type facility built underground. However, the experience to-date indicates that high-pressure pneumatic systems can be used with impunity. There was one line failure under pressure that did nothing more than blow some dust off the floor. After the dust settled, everything was intact. The line did not whip around violently or take off and fly through space. One benefit was quite evident: the little consequence of a pneumatic failure as compared to that of an hydraulic failure. In tests on high-temperature hydraulic systems, a line failure or leak could result in the spraying of hot oil around the laboratory with great hazard to personnel in the area. Hydraulic systems must be closed-loop; hence the circulating fluid eventually reaches ambient temperature. Even in 1,000 F pneumatic systems, on the other hand, the air temperature remains at a relatively low value because the system is open-loop and the air is not recirculated. Tests show that in a 1,000 F environment, the air is around 100 to 139 F because the system is open-loop and air is not circulated. The compressor air is maintained at about 130 F to keep moisture content low.

Another advantage of the pneumatic system is that leakage does not result in the loss of costly media. One hydraulic fluid under test at present costs about $45 per gallon; failure is expensive, considering the loss of fluid and the time required to clean up the residue. Lastly, high-temperature air produces no toxic fumes; hydraulic fluids do.



Continuous Testers check product specifications

PART I PHYSICAL-PROPERTIES INSTRUMENTS

THE GIST: Automatic controls permit a significant increase in the throughput of process plants. Their progress has, however, exaggerated a bottleneck—long time-delays in making laboratory quality-control tests—that still remains. Many new quality-control testers have been developed over recent years to speed up such tests and alleviate this bottleneck. The present article covers continuous quality-control testers that measure physical properties to establish product performance. A subsequent article will cover instruments for measuring chemical properties; it will also contain a list of commercially available physical- and chemical-properties testers.

JOSEPH D. YANAK and ANTHONY M. CALABRESE The M. W. Kellogg Co.

Continuous-test instruments simulate those standard laboratory tests that determine whether products meet performance specifications of interest to the buyer and seller. Readings from such instruments are reproducible measures of a material's physical or chemical property related to product performance. The advantages of such instruments are: the results are more reproducible because the human agent is removed; the time lag between drawing of sample and receipt of test result is drastically reduced; the instruments can be applied to process-monitoring applications, permitting closer control of the process.

Specific gravity—liquid

Expressing the density of petroleum liquids as specific gravity or API gravity at a 60 deg F standard temperature is important in adjusting volumes of products bought and sold to their corresponding weight. The weight is used in determining freight rates, tanker cargoes, and power for pumping. Crude oils are graded according to gravity, since this is a very rough indication of composition. By itself, gravity is not a significant specification, but in combination with other properties, gravity may be correlated with composition (Watson characterization factor) or Btu value. To the process operator, gravity may be a rough indication of closeness of sidestream cuts (especially when compared with gravities of adjacent cuts) or contamination (by, for example, extraction solvent). Because the liquid will rarely be at the standard temperature, a density measurement must be accompanied by its associated temperature to be of any value. Consequently, a density tester must incorporate either constant-temperature control or temperature measurement.

RADIOACTIVE SOURCE — IONIZATION TYPE—The instrument, Figure 1, consists essentially of a radioactive source, an ionization chamber, and a detector that measures the current produced by the ionizing process. The radioactive source (cobalt 60, radium, or strontium 90) is mounted outside the pipe or vessel in which the density is being measured, with the ionization chamber diametrically opposite the source. Radiation from the source ionizes the gas in the chamber, developing an electric current in an external circuit. Density variations in the process liquid affect the amount of radiation reaching the ionization chamber and hence the current output. This electrical signal is amplified and calibrated in specific gravity or density units. Ranges of specific gravity handled by the instrument are between 0.5 and 2.0. The minimum detectable change in specific gravity is 0.1.

DIFFERENTIAL BUBBLER TYPE—Compressed air is passed through two dip tubes immersed at different levels in a measuring chamber containing the process fluid. Taps taken from each dip tube above the liquid level are connected to either side of a differential pressure measuring device or transmitter. The differential pressure P is a function of level difference h between the bottoms of the dip tubes and the liquid density d:

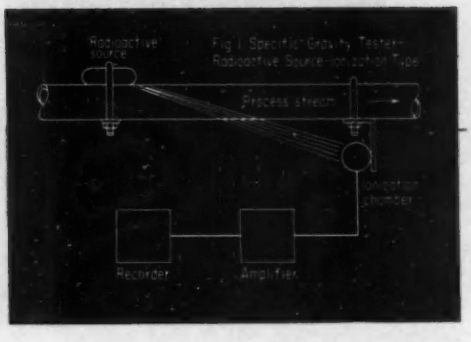
$$P = hd$$

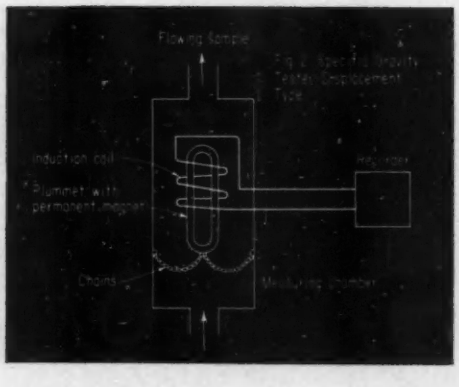
Since h is constant, changes in differential pressure reflect changes in density. The instrument can

measure specific gravity of all liquids that air can be bubbled through. The minimum detectable change is 0.001 specific gravity units.

GRAVIMETRIC TYPE—A delicate balance weighs a fixed volume of flowing fluids. The measuring bulb is suspended from one end of the balance beam and the process fluid enters and leaves the bulb through flexible tubing leads. The instrument may have a direct-connected pointer attached to the balance beam moving on a specific gravity scale; or, by use of an integral air pilot, beam motion may be converted to a pneumatic signal transmitted to a conventional indicator or recorder. The measurement is in terms of specific gravity with reference to water at 60 deg F. Temperature compensation is handled by a bimetallic coil mechanically connected to the pointer but immersed in the process fluid. S.g. ranges available are 0-0.3 through 0-1.2. A change in s.g. as small as 0.001 is detectable.

DISPLACEMENT TYPES—Liquid continuously flows through a vertical tube, Figure 2, in which a totally submerged plummet is attached to the walls by two equal lengths of light chain. The position the plummet assumes in the liquid is directly related to liquid density. A permanent magnet in the plummet moves up and down in an electrical coil, generating a signal proportional to the height, a function of liquid density in the coil. A recent modification employs the coil voltage, through the null-balance principle, to reposition the plummet, so that the reposition motion then is proportional to the sample liquid density.





A variation of this type consists of a hydrometer floating in a measuring chamber. The stem height above the surface measures liquid density. Hydrometer stem level and hence liquid density is measured by a photoelectric cell and light source. The hydrometer stem intercepts, in varying degrees depending on hydrometer level, the amount of radiation reaching the photocell from the light source. The photocell converts the absorbed radiation into an electrical signal proportional to process liquid density. Normal ranges of specific gravity measured by the instrument are 0-0.5 through 0-3.5. Specific gravity changes detectable are as small as 0.005.

Specific gravity—gas

Again, as in liquid density measurements, temperature control is essential; however, now pressure, too, is a variable that must be maintained constant or measured. Gas density is compared with air density to give specific gravity, which may be correlated to give heat value. It will be used as a basis for correcting to a base temperature to give corrected volume when gas is bought or sold. In a gas mixture containing a preponderance of light component (H_2 or methane), gravity will be a rough indication of changes in amount of this component because of the light component's large effect on density. This can tell the operator the H^2 content of reformer recycle gas or methane content of fuel gas.

GRAVIMETRIC TYPE—Two columns of equal length, one through which process gas flows and the other through which air flows, load the two sides of a sensitive balance. The balance-beam deflection is directly related to gas specific gravity. Loading of the balance is accomplished by connecting each column to an inverted bucket, which floats on a liquid seal. The two buckets are suspended from opposite ends of the beam. As the column weight of process gas varies, pressure variations on the under side of the inverted bucket cause the bucket to rise or fall on the liquid seal and cause a beam deflection. Temperature variations are compensated by a bimetallic element which shifts the balance pivot point to the right or left in such a manner as to result in a specific gravity reading relative to air at 60 deg F. Indication is by direct linkage to the balance beam, and a pneumatic signal may be obtained using an air pilot valve. Available s.g. range is 0-0.5 through 0-2.5. Minimum detectable change is 0.001.

CENTRIFUGAL FORCE TYPE—The instrument in Figure 3 utilizes two identical impellers driven by a motor through a belt and pulley system so that they rotate in opposite directions. Air is drawn into one impeller housing while process gas is drawn into the other. An impulse wheel placed opposite each impeller but not connected to the impeller shaft, rotates in the same direction as a result of the centrifugal action of the gas or air being pumped through the impeller housing. A mechanical linkage system connecting the shafts of

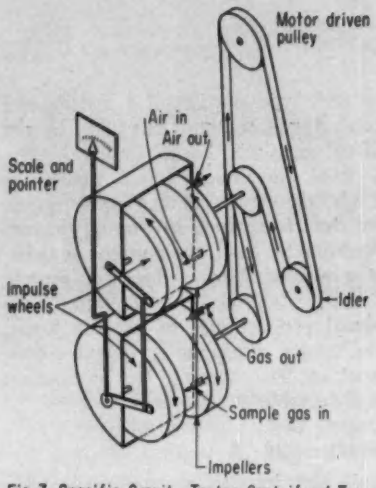


Fig. 3. Specific Gravity Tester-Centrifugal Type.

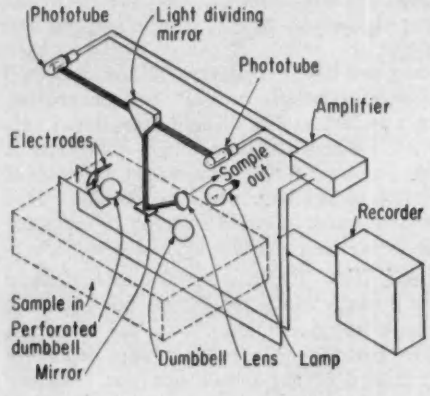


Fig. 4 Specific Gravity Tester-Buoyancy Type.

the impulse wheels indicates torque difference on a scale or chart. The torque difference is related to the air-gas density difference, or specific gravity.

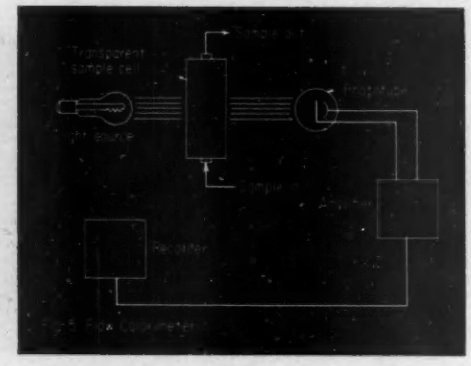
A variation of this type uses the pressure difference developed at the outlets of the impeller housings and translates it to specific gravity unit. Range available is 0-0.50 through 0-3.0. Detectable minimum specific gravity change is less than 0.01.

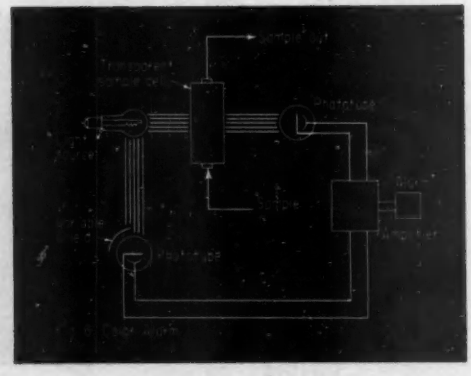
BUOYANCY TYPE—The buoyancy instrument, Figure 4, employs a small hollow dumbbell suspended from a thin filament, one side perforated so as not to be affected by gas density. The other side is gas-tight and will reflect density changes. The perforated dumbbell is electrically conductive and is placed in an electrostatic field produced by two nearby electrodes. As the gas density varies, the dumbbell will shift vertically momentarily; it is brought back to the original equilibrium position by a change in electrostatic field at the electrodes. The change in potential at the electrodes is in direct proportion to the process gas density passing around the dumbbell. An intricate light source, mirror, photocell, and amplifier system achieves null balance. Range normally handled is 0-0.5 through 0-5.0. Minimum detectable change in specific gravity is less than 0.001.

Flow colorimetry

Color of petroleum products may indicate amount of additives, amount of contamination, or degree of refining. When color is a product specification, it may be reported according to an arbitrary scale (ASTM or NPA color number); then the flow colorimeter can be calibrated accordingly. In applications using color as a check on operation, the units are immaterial and arbitrary limits may be set by experience. As a monitor, color may detect thermal decomposition (e.g., of lube stocks) or entrainment of darkly colored contaminants.

FLOW COLORIMETER—Operation of the instrument is based on the variation in light transmission through the sample with changes in sample concentration. In Figure 5, a light source, usually a tungsten lamp, sends a light beam through a transparent sample cell. The process fluid flowing through the cell absorbs a certain portion of the light beam's energy. The weakened beam impinges on a photoelectric tube, developing an electric signal that is amplified for indication or recording. Changes in light transmission and hence phototube output is correlated in terms of concentration units. Transmission-concentration correlations must be obtained experimentally from user's samples.



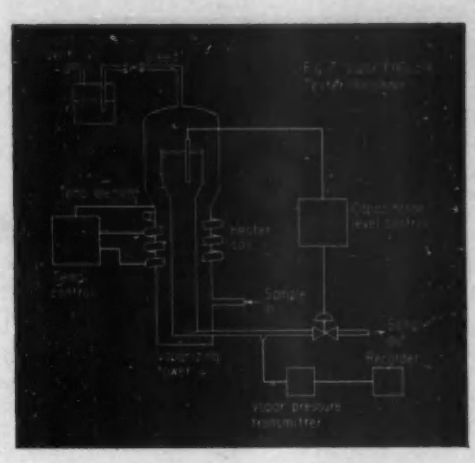


COLOR ALARM—When product color is of primary importance in determining concentration, a monitoring alarm operating on the colorimetric principle, Figure 6, can be used. This unit utilizes two phototubes wired up in opposition. One tube, the reference phototube, has an adjustable shield to vary the amount of light reaching it directly from the light source. The other tube, the sample tube, receives a light beam that has gone through the flowing sample. The instrument is easily calibrated by placing a minimum on-spec color material in the sample cell and balancing out the electronic circuit by varying the shielding of the reference phototube. During on-spec operation, the electronic circuit delivers an unbalanced signal, but when the quality limit is exceeded the instrument returns to the precalibrated balance signal and actuates an alarm. The major limitation with any material is its light transmitting property: a certain minimum amount of transmitted energy is required to actuate the photocells.

Vapor pressure test

The vapor pressure test consists simply of measuring the pressure of a volatile, low-viscosity petroleum product (like gasoline) at 100 deg F. It is a significant measurement for commercial transportation and storage, safety requirements, and, in the case of motor fuels, correlation with engine vapor lock tendencies and starting characteristics. If this test is a specification for a straight-run product like naphtha or natural gasoline, the continuous vapor pressure recorder helps the operator monitor the process. For a blended product like gasoline, vapor pressure measurement is a check on the blending operation. In addition, it guarantees that the maximum amount of butane will be used to meet vapor pressure specification, conserving more valuable components. The recorder makes in-line blending feasible with a saving in expensive rundown tanks.

The test here is essentially a continuous controlled-conditions measurement of a material's vapor pressure, Figure 7. A liquid sample, pumped at a constant rate through a preheater, is raised to the desired test temperature. Next, it flows into the heated measuring chamber thermostated to the temperature of the entering sample. The measuring chamber incorporates an accurate liquid level control, which returns the overflow back to the process, thus maintaining a constant vapor volume in the chamber. The vapor space is vented to atmosphere through a capillary tube, so that when a steady state is achieved the pressure measured in the chamber is the vapor pressure of the sample test temperature. The pressure is measured by a standard pressure transmitter of the appropriate range and is recorded in the usual manner. The instrument accurately maintains the temperature of the sample going to the measuring chamber within narrow limits and also allows a fair span of test temperatures. Available range of vapor pressures is 8 through 750 psig.



Flash-point test

The flash-point test is specified to ascertain safety limitations and to meet ignition specification for kerosene, naphtha, fuel oil (especially domestic), and tractor and diesel fuels. It may also be used to detect contamination by light ends of other products. There are different kinds of laboratory tests, depending on the volatility of the tested product, which in turn determines the design of the test equipment. For example, one semicontinuous tester gives the equivalent of a Tag closed cup test, a specification of domestic fuel oil. When a sidestream product (naphtha, fuel oil) has a flash specification, the continuous flash-point reading can tell the operator whether the amount of stripping is adequate. Shipments out of the refinery can be certified within safe flash limits as the tank car or truck is loaded by running the test (semicontinuously) at the rack.

SEMICONTINUOUS (BATCH TYPE)—The semicontinuous (batch type) instrument is designed to pass or reject a material being tested if its sample exceeds a certain narrow range of flash temperatures. A small measured amount of liquid sample and air are heated separately to the set temperature (i.e., the on-spec flash temperature) in an electrically heated heat exchanger. The two streams mix as they enter a heated and thermostated ignition block containing an ignition chamber, which exposes them to an electrically produced spark. If the flash temperature is exceeded, an explosion will occur, causing an abrupt pressure increase which, in turn, trips a pressure alarm switch. A minimum time cycle—governed by the time required to clear the unit of tested sample—exists between successive tests. About 3 min is required between on-spec samples and 5 min between "bad" ones. The instrument handles flash points from 105 through 115 deg F.

CONTINUOUS FLASH-POINT RECORDER—The sample is introduced, Figure 8, at a temperature considerably below the expected flash point. It is then slowly heated while being mixed with a predetermined amount of air. This mixture flows into a flash chamber where it is exposed to a one-per-sec spark. The sample temperature keeps rising

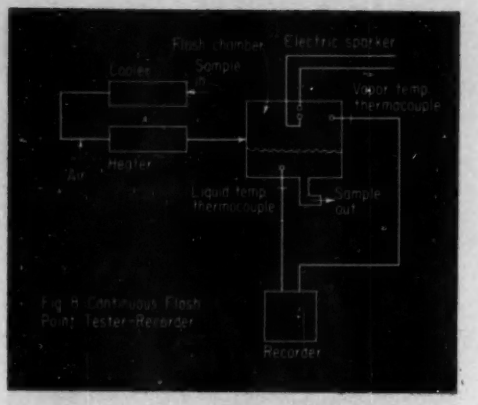


Fig 8. Continuous Flash Point Tester-Recorder

until the spark ignites the vapor; this is the flash point. The sudden increase in vapor temperature at this point causes a large temperature differential between liquid and vapor. Both temperatures are measured, by thermocouples, but only the liquid temperature is recorded. The differential trips a relay, which stops the upward movement of the pen and drives it back downscale. The effect, after several continuous tests, is a saw-tooth record with the high points being the sample flash points. After each flash point the instrument is automatically flushed and the cycle is repeated. Time between flash-point readings averages about 3 min. The instrument is operable on hydrocarbon liquids with flash points between 80 and 160 deg F.

Distillation tests

Distillation information of significance to both seller and user includes initial boiling point, end-point, and intermediate vapor temperatures. The initial boiling point and lower vapor temperatures indicate the amounts of low-boiling components present in the petroleum product under test. In the case of gasoline, these components contribute to ease of starting, quick warmup, and rapid acceleration. In the case of heating oils, the low-boilers contribute to ease of ignition; in the case of solvents, to rate of evaporation. Initial boiling point sometimes indicates product contamination by light-ends components; thus, its measurement can help monitor separation (fractionation or stripping).

The end-point and high vapor temperatures, and the percent residue, indicate the presence of higher boiling components which, in liquid hydrocarbon fuels, contribute to fuel economy. When the end-point temperature indicates contamination by heavy ends, the test for it can also help in monitoring.

Obviously, a piece of test equipment that would be a boon in refinery operations is one that performs a continuous ASTM distillation test. Unfortunately, such a complete tester is not available.

INITIAL BOILING-POINT TESTER—This instrument, Figure 9, can be described as a one-stage distillation column operating at total reflux and at the vaporizing temperature of the sample's lightest components. The measuring chamber, a vertical column about 1 ft long, has its upper chamber water-jacketed to condense all vapors for total reflux action. In the bottom section, an overflow dam maintains constant liquid level while an electric immersion heater maintains constant vapor boilup. Column feed, controlled at a constant flow rate, enters the bottom via the annulus between two concentric pipes. Column overflow, now at increased temperature, is discarded through the inner pipe, thereby preheating the feed stream. A small restriction vents the column, but as long as there is sufficient cooling (total condensation) there will be no vapor loss. A thermocouple in the vapor space accurately and continuously measures initial boiling point temperature, provided stable conditions

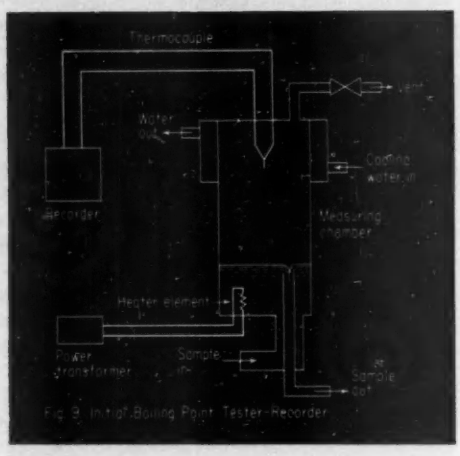


Fig 9. Initial Boiling Point Tester-Recorder

are maintained in the column. The temperature can be recorded on any suitable electronic recorder. The operating range is 200 to 400 deg F.

END-POINT RECORDER—This instrument operates on a cyclic basis with samples being introduced manually. (However, with slight modification the instrument could probably be converted to an automatic continuous-cyclic design.) The tester consists of a distillation flask with an attached temperature-measuring circuit. A sample, with enough excess to purge out any residue from the previous run, is introduced. Heat is applied to the flask and the distillation temperature is recorded. The temperature reaches a maximum (the end-point) and then falls off rapidly as the flask boils dry. Generally, the cycle averages about 20 min per run. The operating range is 225 to 675 deg F with stated reproducibility of plus or minus 2 deg F.

Viscosity also specifies product performance. See "Controlling Fluid Processes With Continuous Viscometers", A. Beerbower, CONTROL ENGINEERING, June 1958, pp. 107-112.

Guides to Control of Metal Properties with Eddy Currents

GLENN O. McCLURG, Magnaflux Corp.

The fields due to eddy currents induced in a metal piece by an ac-excited coil interact with the coil-supported field to change the coil's apparent impedance. In other words, the magnitude and phase (relative to the voltage applied) of the current which will flow in a coil placed near a metal sample, vary with the properties that affect eddy currents in the metal, and with its coupling to the coil. This effect has seen growing use as a means of nondestructive production testing of metals, both ferrous and nonferrous in many kinds of finished shapes, for various kinds of defects.

It is possible, however, to do more than recognize some variation from a norm for a go/no-go rejection test. By proper adjustment of excitation frequency, together with phase and magnitude discrimination, detection of a variation in one particular property of a metal is possible. This, then, suggests that eddy-current coils and associated exciting and discriminating equipment might be used as sensing transducers in control systems. Metal properties that affect induced eddy currents, and hence can feasibly be used as the basis for control include the following:

- electrical conductivity
- magnetic permeability
- dielectric susceptibility
- size and shape
- hardness

As indicated above, the induced eddy currents are also a function of the applied frequency and the coupling between the coil and the metal.

This article includes charts which show the effects on the impedance of the test coil due to dimensions, frequency, conductivity, wall thickness and eccentricity, permeability, and various defects in rods and tubes. They are the work of Dr. Friedrich Foerster, of Reutlingen, Germany (Ref. 3). These charts are only for use with the feed-through type of coil, a circumferential test coil through which the part to be tested is passed. The theory of this type of coil has been worked out and verified experimentally.

These curves illustrate the magnitude and phase changes in coil impedance that occur due to variation of one property at a time, and thus can be useful in determining the circuitry necessary for control or detection of a change in one of these variables.

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3. *THEORETICAL AND EXPERIMENTAL BASIS FOR NON-DESTRUCTIVE TESTING WITH EDDY-CURRENT METHODS. IV—PRACTICAL EDDY-CURRENT INSTRUMENT WITH FEED-THROUGH COILS FOR QUANTITATIVE NON-DESTRUCTIVE MATERIAL TESTING*, F. Foerster, "Zeitschrift fuer Metallkunde", Vol. 45, No. 4. pp. 180-186 (1954).

Conductivity

FIG. 1

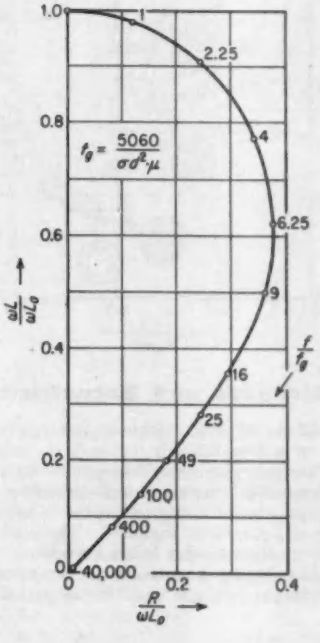
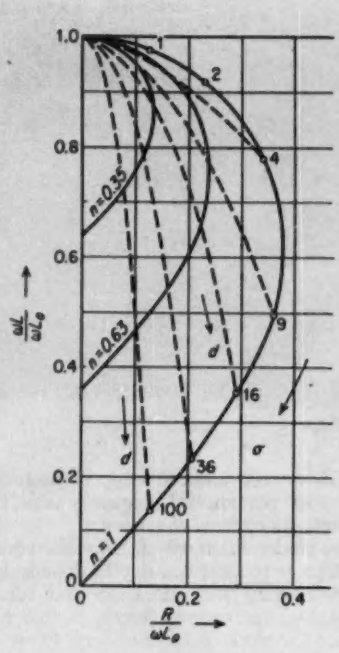


FIG. 1. Variation in reactive and resistive components of impedance of feed-through type of eddy-current test coil (normalized by dividing by impedance of empty coil, ωL_0, assuming empty coil has negligible resistance) for nonmagnetic rods of various conductivities, σ. Ratio f/f_g is that of applied frequency to characteristic frequency of object under test—a function of test object diameter d, permeability μ, and conductivity σ. For nonmagnetic materials $\mu = 1$ = constant, and for this figure diameter d equals the inside diameter of the test coil. The only variable, then, is conductivity, σ. The point 4 on the curve thus represents the effect of a material with four times the conductivity of point 1 for that size test coil.

FIG. 2



Dimension

FIG. 2. Impedance curves of Figure 1 for nonmagnetic rods in feed-through type of eddy-current test coil, expanded to include effect of fill factor, η. Fill factor is ratio of area of test object to area of inside of coil, or d^2/d_c^2. Curve corresponding to $\eta=1$ is the same curve shown in Figure 1. The dashed curves join the points representing the impedance of the coil when the only change in the coil and test object system is a change in the diameter of the test object. Notice that a change in voltage across the test coil due to a change in diameter will differ in phase from a change in voltage caused by a change in conductivity. Thus, dimension changes can be distinguished from conductivity changes by phase-sensitive circuits.

FIG. 4

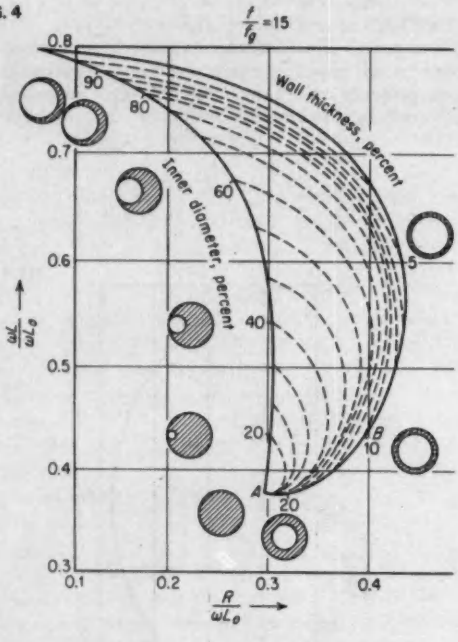
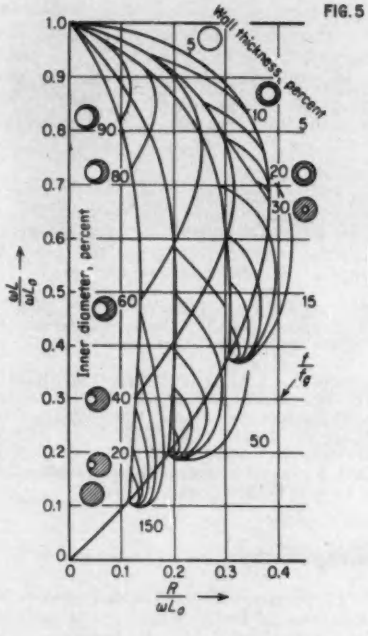


FIG. 5

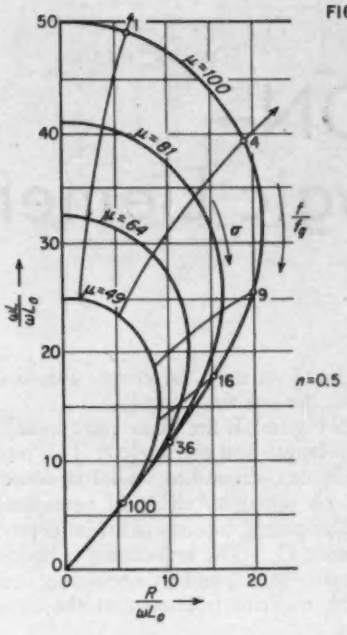


Wall Thickness and Eccentricity

FIG. 4. Effects of wall thickness and eccentricity on impedance of a feed-through test coil for nonmagnetic tubing. Curves are for a single-frequency ratio $f/f_g=15$. Point A represents maximum wall thickness and zero eccentricity (i.e., a solid rod) and has the values of impedance shown at $f/f_g=15$ on Figure 1. The solid curve on the right shows the variation in the impedance of the test coil with wall thickness in percent for zero eccentricity; the solid curve on the left, the variation in impedance with inner diameter in percent for maximum eccentricity. The dashed curves show the variation for constant inner diameter, varying only eccentricity from zero to maximum. Point B, then, represents the impedance of nonmagnetic tubing, $\eta=1$, $f/f_g=15$, with 10 percent wall thickness (80 percent inner diameter) and zero eccentricity.

FIG. 5. Curves show how effects of wall thickness and eccentricity superimpose on curve of Figure 1 for frequency ratios f/f_g of 5, 15, 50, and 150.

FIG. 3



Permeability

FIG. 3. Adding the variable permeability to the curves of Figures 1 and 2 produces a whole family of curves, of which this is the one for a fill-factor $\eta = \frac{1}{2}$ for magnetic rods with permeabilities between 49 and 100 gausses/oersted. Note the large change in the values of normalized reactance and resistance along the ordinate and abscissa from Figures 1 and 2. The dashed curves join the points representing the impedance of a coil when the only change in the coil and test object system is a change in the permeability of the test object. A change in diameter causes an impedance change in the same direction as a change in permeability. For low values of f/f_g, a change in conductivity causes a change in impedance at practically right angles to a change due to permeability, and thus the effects of permeability and conductivity can be distinguished in this range.

FIG. 6

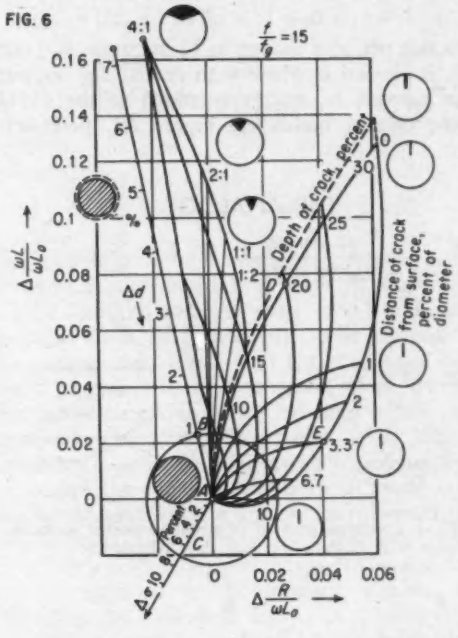
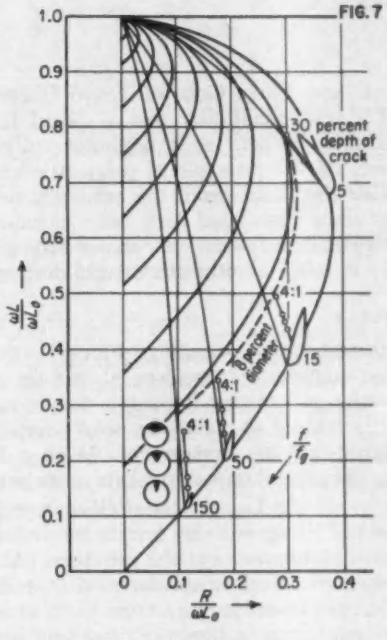


FIG. 7



Surface and Subsurface Cracks

FIG. 6. Curves showing the percent change in test-coil impedance due to surface or subsurface cracks vary widely with the frequency ratio f/f_g. These were determined empirically for nonmagnetic rods at $f/f_g = 15$. Point A represents the point $f/f_g = 15$ on Figure 1. As in Figure 1, a change in conductivity of 5 percent would cause the test-coil impedance to move to point C. A decrease in diameter of 1 percent would move the impedance to point B (see Figure 2). A thin surface crack with a depth 20 percent of rod diameter would move the impedance to point D. Likewise, if the top of a crack of 30 percent depth were 3.3 percent below the surface, the impedance would become that at point E. V-shaped surface defects with various ratios of width to depth affect the coil impedance as shown.

A circle centered on point A gives the percent change in each of the three variables (diameter, conductivity, and defects) to cause the same change in the magnitude of impedance. Thus, a 1-percent change in diameter produces the same change, in magnitude, as a 7-percent change in conductivity or a 5-percent depth-surface crack. Phase-sensitive circuits are therefore necessary to distinguish between these variables.

FIG. 7. Curves superimposing impedance changes due to defects detailed in Figure 6 on curves of Figure 2, for ratios f/f_g of 5, 15, 50, and 150, in nonmagnetic rods.

THE PARAMETRON— An Amplifying Logic Element

HIROSHI TERADA, Tokyo Denki Kagaku Kogyo, Ltd.

THE GIST: Probably the most significant recent Japanese development is the parametron, a bistable magnetic circuit capable of self-limiting amplification. Operating on a principle well-known in the field of nonlinear mechanics, this relatively simple device makes possible the construction of all-magnetic digital computers that are virtually maintenance-free. Its one serious drawback, which may soon be eliminated, is a speed limitation imposed by its high-frequency power requirement.

Five years ago, Eiichi Goto of Tokyo University developed a new circuit that uses a special ferrite as the essential element of a nonlinear reactance and operates on the principle of parametric excitation. Called the parametron, this relatively simple circuit has since been used as a basic element in electronic digital computers, telephone dialing systems, and a number of automatic control devices.

How it works

To understand the operating principle of the parametron, consider the mechanical analogy of a pendulum arranged so that its length can be varied harmonically without changing the pivot point. Figure 1A shows such an arrangement. With a fixed length L_{av}, the pendulum will oscillate at its natural frequency, $\omega_n = \sqrt{g/L_{av}}$, the bob following path a. Tension in the string will vary from a maximum at midposition to a minimum at the extremes. (At the extreme positions no centrifugal force exists, and the axial weight component is a minimum.) If, in addition to this natural oscillation, the pendulum length is varied at a frequency $\omega_L = 2\omega_n$, the bob can be made to describe path b. Moving the bob up as it passes the midposition puts work into the system. Lowering it near the extremes takes work out of the system. However, since tension opposing the motion is greater at midposition than at the extremes, the system receives a net work input which causes an increase in the amplitude of oscillation. Regardless of how small the initial amplitude, it will continue to build up until the energy absorbed by friction equals the net work input.

Note in Figure 1B the phase relationship between pendulum length and the angle θ. This must always be 0 or 180 deg, depending on initial conditions.

Figure 2A shows an electrical equivalent to this system. The circuit consists of an inductance L and a capacitance C_o. The inductance is divided into a fixed component, L_o, and an alternating component, L_v. If the resonant frequency of the circuit is defined as

$$f_r = \frac{1}{2\pi\sqrt{L_o C_o}}$$

the frequency with which L_v must be varied is $2f_r$, and

$$L = L_o + L_v = L_o + \Delta L \sin 2\pi (2f_r)\, t$$

When this periodic change in L, or parametric excitation, is applied in phase with or 180 deg opposed to the current, i_f, energy is added to the circuit and the current builds up. Figure 2B shows why

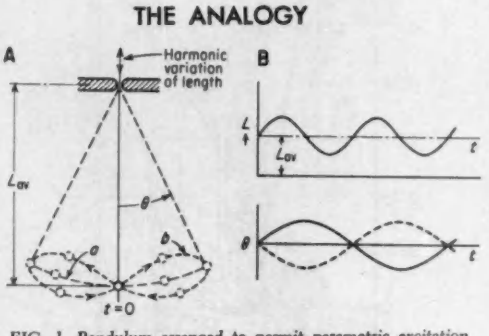


FIG. 1. Pendulum arranged to permit parametric excitation. Curves at B illustrate the dual phase relationship.

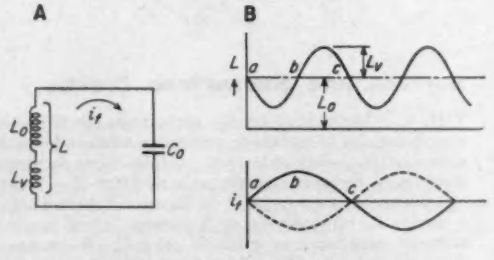


FIG. 2. Electrical equivalent of the pendulum system shown in Figure 1.

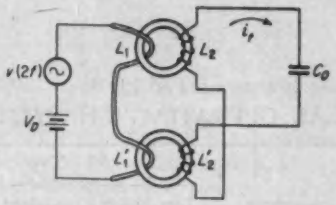


FIG. 3. Basic parametron circuit shows the series-opposition connection that prevents direct transformation.

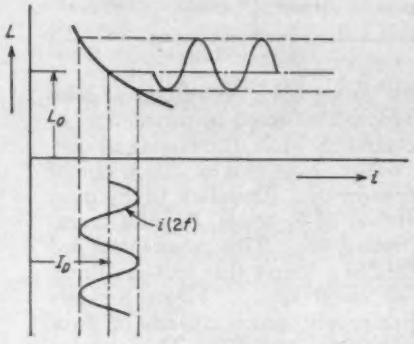


FIG. 4. Secondary inductance varies with the 2f current.

CIRCUIT CHARACTERISTICS

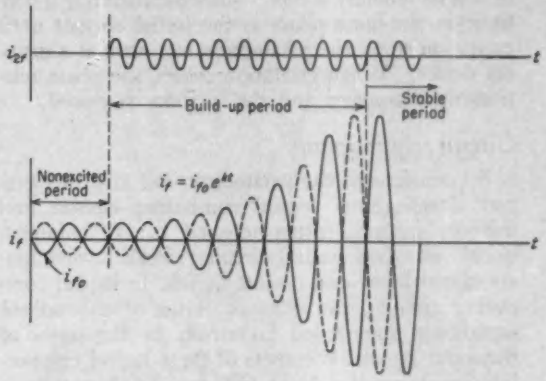


FIG. 5. Current builds up in the secondary until losses balance the energy input.

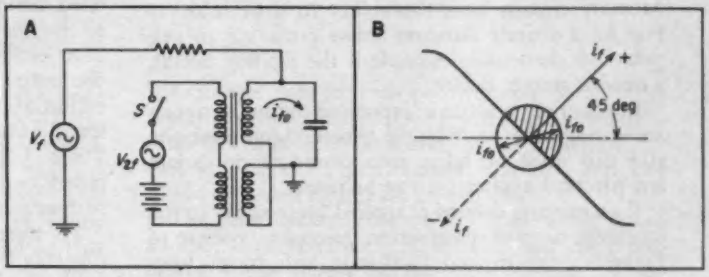


FIG. 6. When 2f excitation is applied, the secondary current must assume one of the two phase relationships shown in diagram B.

the net energy of the circuit must increase. Between *a* and *b* the inductance, *L*, is below its original value. Hence induced voltage must also be below its original value. At the same time current, i_f, is increasing. Between *b* and *c* the induced voltage must be higher than its original value. Here, the current is dropping. An induced voltage always opposes a change in current and, under the above conditions, its opposition to an increasing current is weaker than its opposition to a falling current. Energy added takes the form of increased current.

The actual parametron circuit is shown in Figure 3. Here a dc bias, I_D, and a high-frequency current, i_{2f}, are supplied to the primary, winding $L_1L'_1$. Winding the secondary, $L_2L'_2$, in series opposition as shown prevents any direct transformation. However, because of the nonlinearity of the core material, the secondary inductance will respond to the primary currents as in Figure 4. Thus, by means of the parametron, the circuit in Figure 2 can be realized. This circuit's secondary current will increase as $i_f = i_{fo} \exp [kt + j(2\pi ft)]$.

Figure 5 illustrates the current build-up. The stable period starts when the actual circuit losses have become sufficient to offset the net energy input. The solid- and broken-line waveforms indicate the two possible phases.

A versatile component

In operation, the parametron exhibits three rather important characteristics. First there is its phase quantizing action, illustrated by Figure 6. Here an external voltage source at frequency *f* sets up the initial current i_{fo}. When switch S is closed, applying 2*f* excitation, oscillation must occur in one of the two phases shown in Figure 6B. If the current i_{fo} lies between minus 45 and plus 135 deg (in the shaded area) the final oscillation i_f will be in phase with the 2*f* excitation. If i_{fo} falls outside this region, i_f will be 180 deg out of phase.

Next there is the amplifying and regulating action of the parametron. The waveform of Figure 5 shows how the oscillation amplitude increases as an exponential function and stabilizes at a particular amplitude. The parametron therefore is a self-limiting amplifier. This action, while different from linear amplification, is just as useful in certain applications; for example, in the pulse reforming circuits of ordinary computers.

The third important characteristic of the parame-

tron is its memory action. Since oscillation will continue in the same phase as the initial current until excitation stops, the parametron can serve as a memory device. When excitation ceases, the phase relationship disappears and the memory is erased.

Circuit requirements

Applications of the parametron fall into two general classifications, logical computing circuits and memory circuits (often referred to as "combinational" and "sequential" circuits). Both involve binary-valued input and output signals. In logical computing circuits, the state or states of the output signals are determined exclusively by the states of the input signals. Elements of these logical computing circuits are the AND, OR, and NOT circuits.

The output signals of memory circuits, however, are influenced not only by the state of the present input signal, but also by that of the previous one. Memory circuits have the ability to store information for a definite duration before providing an output. An elementary example is the flip-flop circuit, a one-bit storage device.

In parametron systems, input and output terminals are distinguished only by the time division principle, and this must be taken into consideration before any practical application can be made.

If an exciting current is applied successively to the resistance-coupled parametron resonator system of Figure 7, the excited oscillation will travel from the first parametron, P_1, to the second, P_2, from P_2 to P_3, etc. This circuit then constitutes a delay line in which information stored in parametron P_1 is transmitted successively while maintaining its original phase relationship. Note that excitation cannot be applied independently. Excitation of P_2 must start before excitation of P_1 ceases, P_3 must be excited before P_2 ceases, etc. This requirement led to the development of a source that provides three-beat excitation by on-off keying. Figure 8 shows the output of this supply, which consists of three excitation currents I_e, II_e, and III_e. This arrangement forces information to travel unidirectionally. Table I gives typical operating frequencies and power requirements for three types of parametrons currently in use.

To store information, the parametrons must be ring-coupled; i.e., the output of the last must be fed back to the first. Also, because of the intermit-

TABLE I
TYPICAL OPERATING CHARACTERISTICS

Characteristic	Type		
	Low-power	Standard	High-speed
Exciting frequency	300 Kc	2 Mc	6 Mc
Three-beat frequency	2 Kc	30 Kc	150 Kc
Power per element	4 mw	15 mw	80 mw

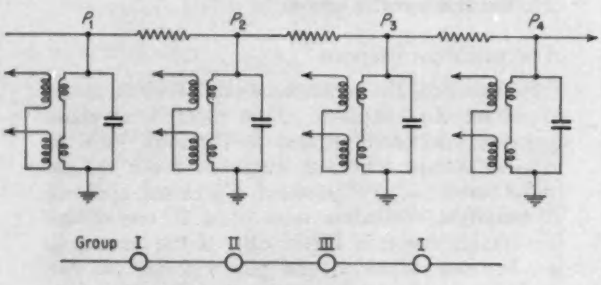


FIG. 7. Simple delay line using parametrons.

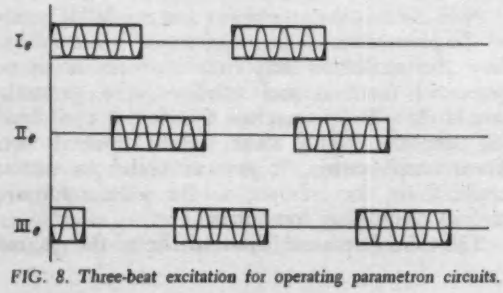


FIG. 8. Three-beat excitation for operating parametron circuits.

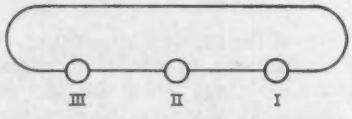


FIG. 9. Simple flip-flop circuit, or "constant" parametron, serves as a phase standard.

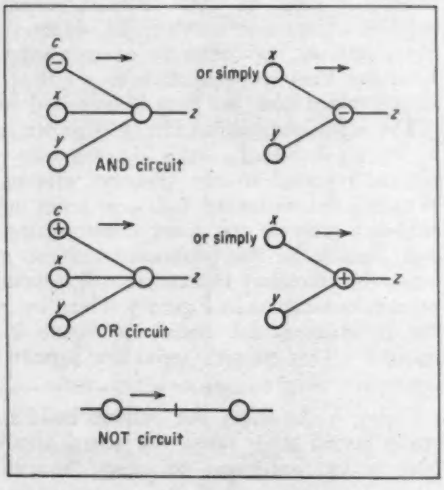


FIG. 10. Parametrons arranged to provide the three basic logic elements.

tent excitation, each bit of information stored requires three parametrons.

Since the binary values of the parametron are simply a matter of phase relationship, some sort of phase standard must be used. A convenient device for this purpose is the flip-flop circuit of Figure 9.

Logic elements

To simplify the following discussion, in-phase oscillation will be referred to as state 1, and phase-opposed oscillation as state 0. In the illustrations these will be indicated as (+) or (−), respectively.

Whether a parametron oscillates in state 1 or state 0 depends solely on the majority of the input signals. Obviously, to operate on this majority decision principle, a parametron must have an odd number of inputs, one- and three-input systems being fairly common. Where five- and seven-input systems are used, the problem of matching parametron characteristics becomes greater. However, these latter systems have greater circuit simplicity and faster computing action.

Figure 10 illustrates schematic forms of the three basic logic elements, the AND, OR, and NOT circuits. The first two represent three-input systems. In both of these, one input, c, serves as a "bias signal" and always oscillates in the same state. This permits use of the simplified schematic in which the symbol for such an input is eliminated and its state simply shown as (+) or (−) in the next parametron.

In the AND circuit the state of the bias signal c is 0. For the output to have a 1 state, both x and y must be in state 1 (one input would cancel the bias effect, the other would determine the phase of the output).

In the OR circuit the state of the bias is 1, and if either x or y (or both) are in state 1, output z will also be in state 1.

The NOT circuit is obtained by inserting a phase inverter transformer between two parametrons. Its symbol is simply a short line cutting the connection at right angles, as shown at the bottom of Figure 10.

CIRCUIT APPLICATION

1. Binary counter

In a binary counter states 1 and 0 are inverted by each input signal. Figure 11 shows a fundamental part of the counter circuit. While the circuit is inactive, parametrons 101 and 102 are in state 0 (negative). Then, by the "majority principle" all the parametrons in the circuit produce a state 0 or negative output.

When the first positive input signal enters the circuit, parametrons 201 and 301 receive two state 1 and one state 0 inputs and become positive. When another positive input occurs, parametron 102 becomes positive and 301 reverts to the 0 state. Inspection of the circuit will show that parametron

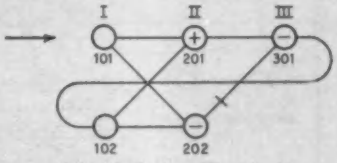


FIG. 11. Basic counter circuit.

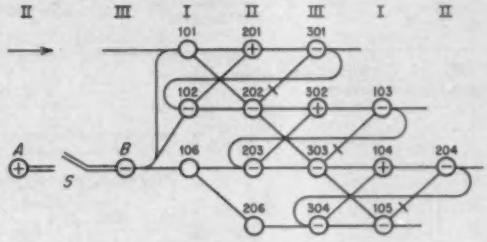


FIG. 12. Counter circuit in which the switch S initiates the counting operation.

301 changes state for each positive input at 101. In binary notation, the output of parametron 301 indicates the figure 2^0. Similarly, in the extended circuit of Figure 12, parametrons 301, 103, and 204 would represent figures 2^0, 2^1, and 2^2.

This new circuit (Figure 12) also shows some additional parametrons (*A*, *B*, 106, and 206) preceding those shown in the basic circuit. Their function is quite simple. With switch *S* open, the negative bias signals on 101, 102, 203, and 304 produce negative outputs at 301, 103, and 204, which, as mentioned above, represent powers of the base 2. Parametrons *A* and *B* are doubly coupled so that when switch *S* is closed, *B* receives two positive inputs, thereby becoming positive and making 106 and 206 positive, too. These positive outputs (from *B*, 106, and 206) cancel the effect of the negative bias on 101, 102, 203, and 304. Output signals from these four parametrons will then depend on the state of their third input.

2. Clock circuits

Synchronizing the switching action in computers usually requires some type of clock circuit. A special circuit could, of course, be devised to provide this action, but a slight modification of the counter circuit serves the purpose. Figure 13 illustrates a typical design for generating an output signal for every eighth input. An output for every 16 or 32 pulses simply requires additional stages.

Some clock configurations combine flip-flops with NOT circuits as shown in Figure 14. This represents a 1:3 clock, in which parametron P_3 provides a positive output on every third pulse. Suitable combinations of this circuit could also provide 1:6 and 1:12 clocks.

The clock circuits described so far fall into either the $1:2^n$ or $1\cdot(2^n\text{-}1)$ class. Special problems, how-

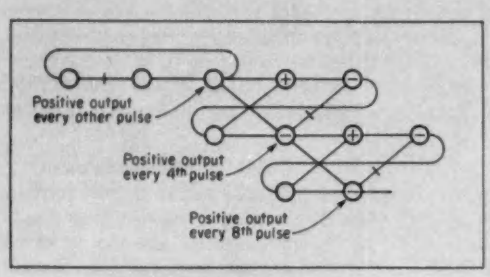


FIG. 13. Counter circuit arranged to provide 1:8 clock action.

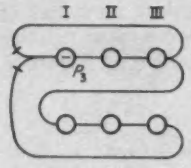


FIG. 14. A 1:3 circuit.

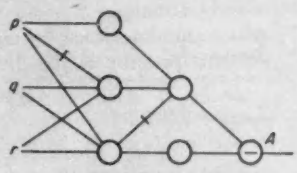


FIG. 16. Outputs of three clock circuits can be combined as shown to produce a 1:pqr clock.

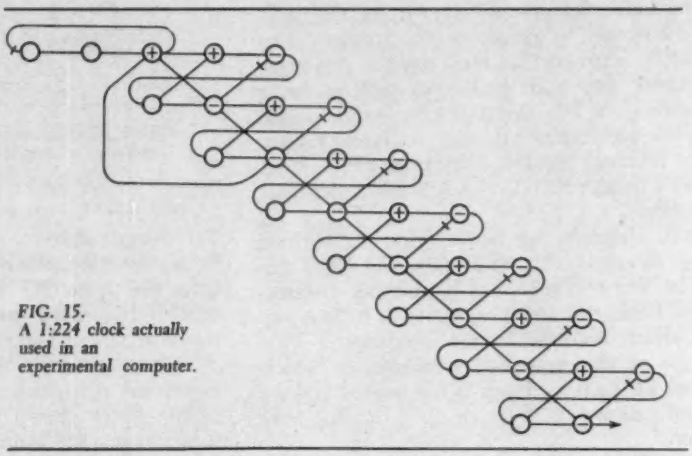


FIG. 15. A 1:224 clock actually used in an experimental computer.

ever, might require special forms. One example would be a $1:(2^n-1)\cdot 2^m$ clock. An actual circuit satisfying this form is the 1:224 clock used in an experimental computer at Tokyo University. (Here the exponents n and m are 3 and 5, respectively.) As shown in Figure 15, this is actually an eighth-stage binary counter with a feedback path between the third and first stages. This feedback arrangement makes a 1:7 clock out of the first three stages. The five remaining stages constitute a 1:32 clock, and the overall circuit then delivers one positive output signal for each $7 \times 32 = 224$ pulses.

Clock circuits requiring any ratio, 1:m, can be simplified considerably when m can be treated as $p \times q$ or $p \times q \times r$. Figure 16 illustrates the latter case. Here p, q, and r represent the outputs of 1:p, 1:q, and 1:r clocks. Connected as shown, parametron A will produce a positive output only when all three inputs are positive.

TABLE II–CONVERTER COMBINATIONS

	X_3	X_2	X_1	Output
0	0	0	0	Z_0
1	0	0	1	Z_1
2	0	1	0	Z_2
3	0	1	1	Z_3
4	1	0	0	Z_4
5	1	0	1	Z_5
6	1	1	0	Z_6
7	1	1	1	Z_7

3. *Binary adder*

If X_0 and Y_0 represent the last digits in two binary numbers to be added, the operation can be expressed as $X_0 + Y_0 = C_1 + Z_0$

where Z_0 represents a sum and C_1 a carry to the next stage. The circuit arrangement of Figure 17 satisfies this relationship. Subsequent additions are performed on similar circuits. In these, however, the bias signals are not fixed, but depend on the state of the preceding carry. Figure 18 shows a typical binary adder circuit. The portion of the circuit within the broken line represents a complete adder stage and satisfies the more general expression,

$$X_i + Y_i + C_i = C_{i+1} + Z_i$$

Parametron circuits for adding binary-coded decimal inputs can also be developed by suitable extension of this basic adder. One example would be a circuit in which the inputs are expressed in the excess-3 code. In this case, the circuit of Figure 18 would be modified by a corrector circuit.

4. Multiplication in binary code

Multiplication can be thought of as a process involving repeated addition and shifting. These operations can be performed on binary numbers by using the shift-register gate accumulator arrangement shown in Figure 19. When the shift signal is negative, stored information simply circulates in the flip-flop circuits *A*, *B*, *C*, and *D*, because of the bias signals present. A positive shift signal cancels the bias on parametrons *a*, *b*, *c*, and *d*, and permits shifting of information from *A* to *B*, *B* to *C*, etc. After each shift, the signals are gated to the accumulator, where they are summed up.

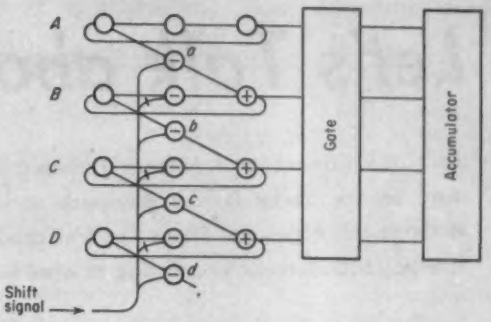


FIG. 19. Shift register, gate, and accumulator arranged to permit multiplication in binary code.

5. Parallel-to-serial converter

As a final illustration of the parametron's versatility, consider the circuit of Figure 20. Suppose the signals X_0, X_1, and X_2 represent the output of a 0 to 7 counter circuit with X_0 denoting the 2^0 position, X_1 the 2^1 position, and X_2 the 2^2 position. When X_0 is 0, signals Z_1, Z_3, Z_5 and Z_7 are cut off in the first stage while Z_0, Z_2, Z_4, and Z_6 are allowed to pass. If X_1 is also 0, signals Z_2 and Z_6 are cut off and Z_0 and Z_4 allowed to pass. A third negative signal ($X_2 = 0$) cuts off Z_4, and Z_0 passes to the output parametron. This and seven other possible combinations of the input signals are shown in Table II. Thus the three-bit, 0 to 7 counter permits the circuit to read out serially the Z_0 to Z_7 parallel input. Functionally, the circuit reverses the operation performed by the shift register in Figure 19, in which a serial input can be converted to a parallel output.

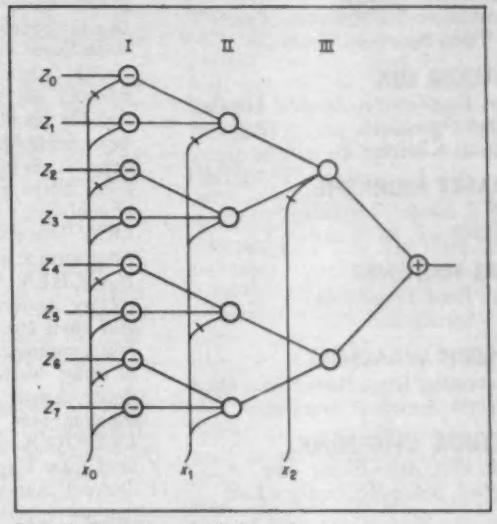


FIG. 20. Parametron circuit for performing a parallel-to-serial conversion.

BINARY ADDERS

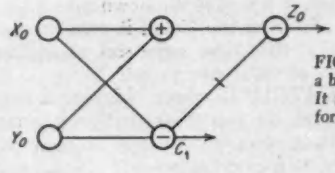


FIG. 17. First part of a basic adder circuit. It requires no provision for a preceding carry.

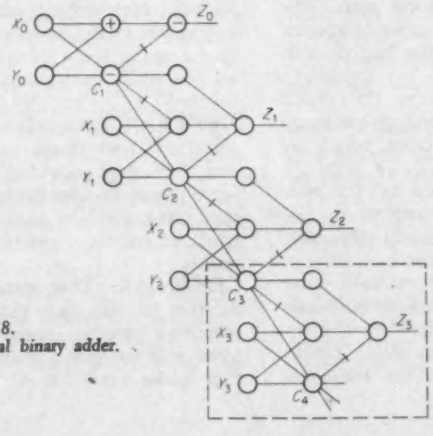


FIG.18. Typical binary adder.

Advantages and disadvantages

The few typical circuits described above by no means exhaust the subject of parametron application. They serve merely to illustrate a few areas in which this versatile component has been successfully used.

Comparing the parametron with diodes and other active circuit elements reveals several distinct advantages of the parametron:

- additional amplifying and amplitude limiting circuits are unnecessary since the parametron itself is an amplifying and self-limiting element
- absence of active components in the parametron circuits assures practically perfect reliability over years of operation
- while operating theory may appear complicated, the circuits themselves are extremely simple.
- maintenance and replacement costs as well as initial computer costs are reduced considerably.

Disadvantages are relatively few. Perhaps the most important is the high frequency power requirement, which increases with the speed of the computer. However, in time, this too may be eliminated.

Let's Talk about LUNIK

Six Cape Canaveral engineers gathered around a tape recorder to discuss CtE's story on the Soviet Lunik's guidance and instrumentation (Feb. '59, p. 168). McGraw-Hill Newsman Doug Dederer prodded them with questions, the answers to which broaden our knowledge of what Russian space scientists are really doing.

The Participants:

DONALD FREER
Rocketdyne Field Service Div. of North American Aviation

WALKER DIX
Mgr. Engineering, Atlantic Missile Range Operations, General Electric Co.

ROBERT MURKSHE
Staff Engineer, Instrumentation Engineering, RCA Service Co.

EARL HATCHER
Mgr., Data Translation, RCA Service Co.

JOSEPH WAMBOLT
Engineering Rep., Rocketdyne Div. of North American Aviation.

GEORGE CHERNIAK
Tech. Dir., Atlas Flight Test Program, Space Technology Lab.

DEDERER: Probably one of the things that interests most control engineers is guidance. The Russian system is called "time-guidance". Does the phrase "time guided" originate with the aluminum card program unit contained in the rocket?

HATCHER: That's the way I read it. And there is a program card incorporated at each ground station. That means taking data on the entire trajectory at a very high sampling rate, then comparing it at discrete time intervals.

DIX: I got the impression their time sequence was obtained directly from cards. They control everything from this fixed predetermined idealic profile. It pins down their attitude information, trajectory, velocity.

HATCHER: The story indicates that at each one of these 12 sites the Russians have incorporated program cards. That would mean they are comparing the position of the tracker against a program card at each site; then transmitting the error to the central computer. But 12 inputs to a computer at any high sampling rate is a pretty big job even for, say, an IBM 704, so I presume they are doing this at a low sampling rate. However the story also makes mention of a site computer. It said, "Data from these three methods (they are talking about doppler, radar and phototheodolite) are supplied to a computer and the results then sent to an IBM tape electronic computer." Well, it depends on how you define computer here. Perhaps it's a crude definition of computer.

DIX: Nonetheless, it seems they've programmed a very strict trajectory.

HATCHER: Comparing program trajectory against the actual trajectory and then transmitting differences at low sampling rates is a time-check type of thing. Such a procedure would cut down sharply the data input to the big computer.

DEDERER: Most of the missiles fired from Cape Canaveral have dual destruct systems. The ground rules that we operate on require some sort of a range safety command system. I notice the Russians left no allowance for destruct. Instead they cut off the fuel. Do you think that destruct systems would make that much weight difference in such a big rocket?

CHERNIAK: Yes. No matter how much thrust—*every pound counts.* Apparently they have ground rules which allow them to send up a vehicle of this sort and risk the possibility of it getting into trouble and clobbering something.

MURKSHE: We saw a list of the Soviet instrumentation sites and plotted them on a big world map. We found the sites are rather well dispersed in a large circle and the bird does fly over populated areas, so apparently they don't care where the rocket might fall. The tracking sites were all inside all their boundaries, which are rather wide.

DIX: I was impressed by the very heavy emphasis they had on the instrumentation system and the telemetry package they carried.

HATCHER: What were your thoughts on the various instrumentations at all of these sites?

DIX: I was using the word instrumention in regard to the telemetry installation they had. Data acquisition sites! If they are for the purpose of guidance, all of these tracking sites make up a complex installation.

MURKSHE: I get from reading this story that the Russians took some off-the-shelf stock items for their instrumentation system. Certainly there is nothing new about Askania phototheodolites. The Germans used those before the war. And doppler is an old system. Even the radar could be a World War II type of instrumentation, since the article says it used a 12-centimeter wave length.

CHERNIAK: What about the real wild scheme of measuring intended distortion, temperatures, thermal distortions, etc.

DIX: It sounds incompatible with what you infer of the state of the art of their tracking radar. You get the impression that it is relatively crude radar. Then on the other hand, they go to third-order corrections and distortion of the antenna dish, and they are really getting down into the noise. I can't quite reconcile this. When you go to such extremes as this you already have thermal noise accuracy, and then you're trying to dip down into it.

CHERNIAK: Could it possibly mean that they have some sort of sophisticated radar equipment?

HATCHER: Since this was a beam rider, do you think that such corrections were an attempt to keep the beam focused narrowly?

DIX: I doubt it. When you worry about things like sun loading and differential temperature you are talking way down in the hundredths of mils. As far as the beam rider is concerned, all you really care about is that it is pointed.

DEDERER: On a different track, the story says that thrust in the second and third stage provided sufficient reserve power to spin the vehicle to 60 rpm using graphite guidance rudders, while we use the verniers in our space probes.

CHERNIAK: That statement is indicative of the fact that they had sufficient reserve energy to utilize some of it for spin stabilizations, that they make every bit of it count in

terms of thrust. You don't get something for nothing—you burn up a finite quantity of propellants to impart the spin momentum through the vehicle.

DEDERER: How do you think they arrived at their cut-off time?

MURKSHE: It must have been computed first.

FREER: One thing that was interesting to me is the use of acceleration control. What was the necessity for acceleration control if it was a command cut-off? If it was programmed, then you could see why they might use acceleration control.

DEDERER: How would you compare this Russian effort—not to ours particularly, but on its own merits of itself? Is it a crude effort?

MURKSHE: No, I don't think you can call it crude by any stretch of the imagination.

CHERNIAK: I feel that the most significant part of it, as near as you can make out from the story, is that their operation does not involve any major advance in the state of the art. They have done remarkably well with known techniques and in some cases real old techniques. For example, the use of graphite vanes. This seems to be true throughout all of the subsystems involved. There is no indication of advancement in the state of the art.

DEDERER: Don, you mentioned those graphite guidance rudders before; is that first-grade stuff?

FREER: Let's put it this way: as far as we know gimbaling is a more advanced state of the art. Graphite vanes were used in the old V-2 system. It may be indicative of German project engineering.

WAMBOLT: The injector design also reflects German influence. A series of individual injectors, each with its own metering valve, was used; the result is a complex injection system design.

MURKSHE: I would say much of what they did is very similar to what we did with our first Explorer. We took a Redstone booster and attached some available off-the-shelf clusters on top of it, then spun the thing.

HATCHER: Could we say it is a rather clever combination of tried and proven hardware and techniques—a rather complex combination?

DIX: It seems like they built in a lot of redundancy to insure success.

CHERNIAK: They are trying to make sure, as well as they know how, that things would work right at considerable sacrifice of "engineering elegance" and some sacrifice of reliability.

MURKSHE: They picked some basically reliable systems—doppler for example.

DEDERER: What about the thrust potential?

FREER: The engines they used do not seem to be particularly efficient, but they sure have plenty of thrust.

DEDERER: I am trying to visualize this tremendous thrust which adds up to over a million pounds.

WAMBOLT: That in itself doesn't meant a thing—since it's a staged vehicle and specific impulse for each stage is not particularly impressive even with high energy additive. It seems to me the total impulse they gain was by using the two solid-fuel boosters.

DEDERER: Could you hazard a guess on the specific impulse on the first stage?

WAMBOLT: Neglecting the solid boosters, I would say around 230 sec* for the first stage. That, by the way, is in the middle of the operating band of liquid propellant engines.

CHERNIAK: This appears to be again, just a careful job of working with existing hardware. And it should be possible for anyone who has comparable hardware available to them to do the same thing.

DEDERER: How does this compare with the launching of Sputnik III, which weighed considerably more than Lunik? Does this indicate that a different vehicle was used?

MURKSHE: When they launched Sputnik III they were not seeking escape velocity. But I would like to ask Earl if he deduces from this article any advancement in the state of the art of computers or computer techniques over what we have.

HATCHER: That's a tough one. I think they have gone to two measures to cut down the amount of actual information that computers have to use. I don't get the impression here that their central computer is any better or bigger than some that we have. It is hard to glean exactly what they mean by IBM computer in the article—I think this is more of a trade slang. If the Russians are just transmitting differences, they are not putting too much of a workload on the computer. If they are transmitting complete trajectories from each of these 12 sites into a single computer, my comment would be WOW!

DIX: That would certainly take quite a machine to do that.

HATCHER: It looks to me as if they have come up with a rather clever arrangement of utilizing existing proven instrumentation schemes to minimize the computer input.

MURKSHE: From this system as we look at it, it appears to me that the Russians have not progressed in the state of the art of radio interferometers to the degree of sophistication represented by our AZUSA system.

HATCHER: Right. The angle determinations that you can get from the Russian system won't nearly compare with any of our radio interferometer systems. On the other hand, as has been pointed out, they hedge their bet with a lot of redundancy.

DEDERER: Are there any final comments on the propulsion system?

FREER: The second and third stages, as far as I can see, are tried and true developments that have progressed over the years. The first stage, if they are using a single-chamber booster, is in the advanced stages in the development of large engines. If they are using clusters, then they certainly haven't contributed anything to rocket development. In terms of specific impulse, I don't see their reasoning in using high-energy propellants unless they are using it as a crutch. I do think that the booster stage indicates that they have a workable ICBM, whether it's of single- or multiple-chamber design. They are using many techniques that were used in the original V-2 Redstone, such as injector and thrust-chamber design. These indicate an intensive effort to achieve their objective using reliable existent principles at the expense of engineering sophistication. Whether this is important is something else.

DIX: In summarizing my thoughts on the guidance system of this Russian rocket, it seems to me that the Russian system is indeed a most complex affair. In fact, unnecessarily complex with, in effect, two complete guidance systems—one programmed inertial and one radio-command type. To my way of thinking, sophistication does not mean accuracy through complexity; but rather equal or better accuracy with simplification. Their system, while admittedly accurate, shows no advancement in the state of the art of guidance. It does show great redundancy, evidently in an attempt to guarantee accuracy, and this results in tremendous and expensive ground installations plus an added weight burden on the bird. To sum up, they have a good system, but I think needlessly expensive, heavy, and complex.

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* Propellants are rated on the basis of specific impulse, the amount produced by 1 lb of propellant. Since it is equal to the product of thrust (in pounds) and duration of thrust (in seconds) divided by weight of fuel (in pounds), specific impulse is reported in seconds. ED.

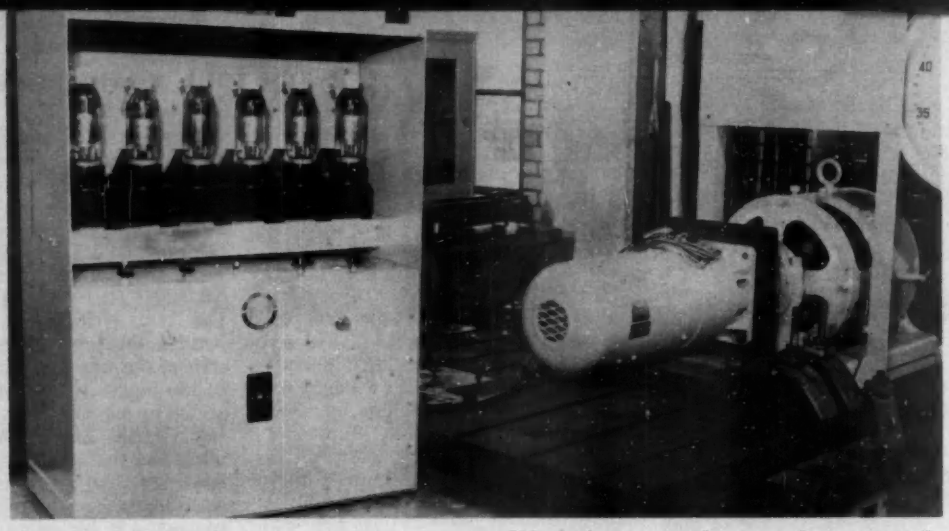


FIG. 1. A test setup shows new thyratron controller driving dynamometer-loaded 1-hp two-phase servomotor.

Use Thyratrons to Control Higher Power Ac Servomotors

EDWARD TAYLOR, Diehl Mfg. Co.,
JAMES BURNETT, Electrons, Inc.

High torque-inertia ratios are available in two-phase ac servomotors (e.g., 10,000 rad/sec^2 acceleration constants at 1 hp). This article describes a new transistor-controlled thyratron control system that gets close to the ultimate performance from motors of this type in the ⅛-to-3-hp range. The circuit produces linear torque vs. error characteristics while controlling both motor phases simultaneously.

Two-phase induction motors have been used successfully in intermittent reversing duty for some years with a manually operated transformer as shown in Figure 2. This circuit utilizes the motor itself with the autotransformer to form a Scott transformation from a three-phase source. The circuit affords both reversibility of the phase rotation, and proportional voltage control of one of the motor phase windings.

A new controller has been designed that uses an autotransformer and the motor to form a Scott transformation from a three-phase source, but in this circuit, Figure 3, the dual control winding and the main winding are connected between the transformer center tap and one of the three phase supply lines through pairs of thyratrons in inverse parallel.

Each thyratron is controlled by a plug-in packaged reset magnetic grid-circuit unit (Ref. 1), driven by transistor amplifiers. Figure 4 is a more complete circuit diagram, simplified only by omission of thyratron bias and filament supplies. Note that tubes *E* and *F* conduct for one direction of motor rotation and tubes *C* and *D* for the other. Polarities and winding senses in the grid circuits are arranged so that if tubes *F* and *E* are conducting, tubes *A* and *B* conduct with the same grid firing angle as *F* and *E*. Likewise, if tubes *C* and *D* are conducting, tubes *A* and *B* conduct with the same grid firing angle as *C* and *D*. Thus the currents in the motor windings are always exactly 90 deg displaced with respect to each other regardless of the firing angle, or of the direction of motor rotation.

Transistor *A* controls the currents in the control circuits of the grid units of tubes *E* and *C*, and the signal voltage determines which shall conduct and at what firing angle. A portion of the output voltage of grid units for tubes *C* and *E* drives the control circuits of the grid units of tubes *F* and *D* to produce equal firing angles of *F* and *E*, or *C* and *D*. This feature is unique to this circuit.

The ac error signal voltage is full-wave rectified and applied to the base and emitter of transistor *B*, which controls the currents in the control circuits of the grid units of tubes *A* and *B*. Thus for any value of input signal voltage, the firing angles of four of the six thyratrons are always equal and the other two are held nonconducting.

Since *both* motor phase voltages are proportionally controlled from all "off" to full "on", the motor torque varies as the square of the voltage. However, the characteristic of the transistor-magnetic grid circuit is nonlinear in the opposite sense, and the result is a torque vs. signal voltage characteristic which is quite linear over a wide range, as shown in Figure 5.

A single transistor may be used to control all six thyratrons, Figure 6, if the grid units for tubes *A* and *B* are designed with twice the usual number of turns on the output winding of the toroidal reactor. The signal transistor is connected in common with four magnetic grid units' control circuits. The transistor base to emitter signal voltage lags or leads by 90 deg the respective magnetic grid unit gate voltages for tubes *A* and *B*, but due to the doubled

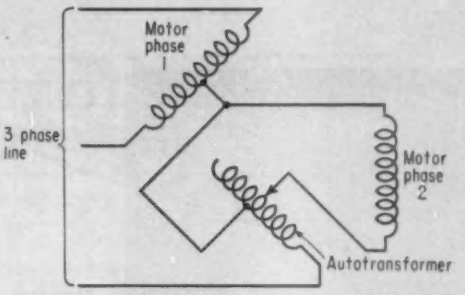


FIG. 2. Two-phase motors with dual control windings have been used with manually variable autotransformers in a Scott connection on a three-phase supply, as shown, to control one motor phase.

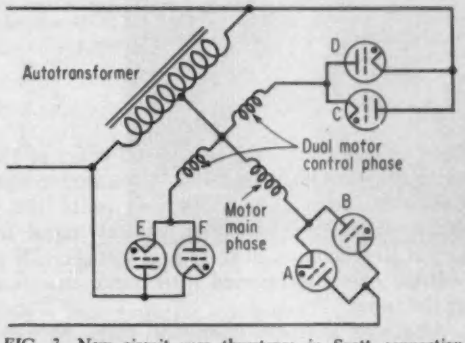


FIG. 3. New circuit uses thyratrons in Scott connection, similar to Figure 1, to control both motor phases. Only four of the thyratrons conduct—A and B with either C and D or E and F, depending on direction of rotation.

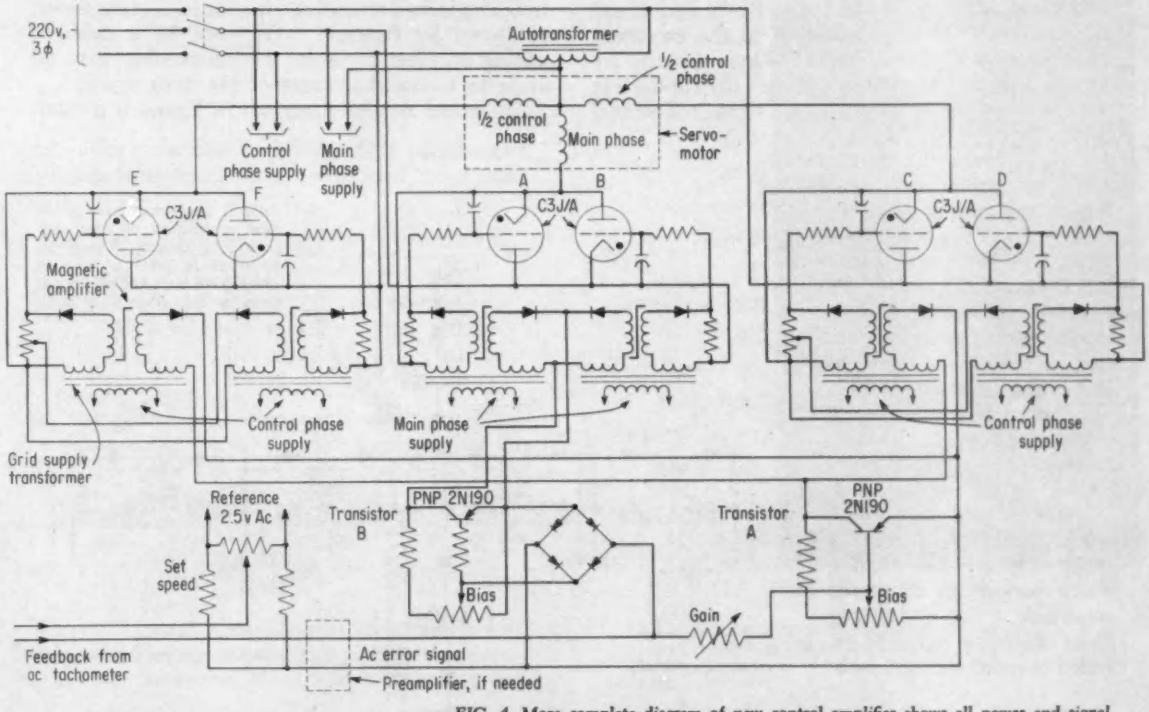


FIG. 4. More complete diagram of new control amplifier shows all power and signal circuits. Thyratron bias and filament circuits are omitted to simplify diagram.

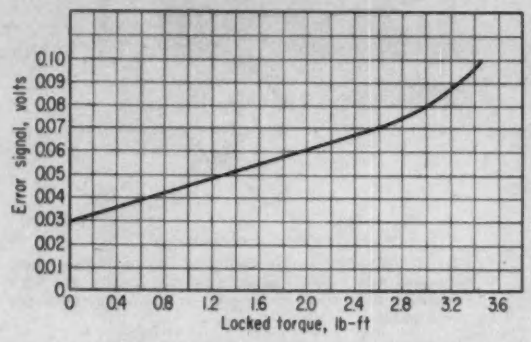


FIG. 5. Locked motor torque produced by new amplifier is linear with error input signal over wide range. Offset at zero torque is due to bias setting on transistor amplifiers and can be reduced to zero. Slope can be varied by gain control.

sensitivity of these two units a full range of 180-deg thyratron control is obtained. Also, due to the one-half-cycle integration of the grid units, the firing angles of A and B are approximately equal regardless of the direction of the signal voltage. Dc signal voltages may also be used with minor modifications of the input circuits.

Although a single transistor may control both phases, two separate transistor driver stages are used in the circuit illustrated, one for the main and one for the control tubes, so that standard packaged magnetic grid units can be used. The gain control adjusts the level of one channel with respect to the other. Thus the main phase may be excited at any selected power level with respect to the excitation applied to the control phase. These circuits are designed so that the transistors are fully conducting with no error or reference input signal. The two bias potentiometers shown in Figure 4 permit this adjustment. An input error signal reduces the conduction of the transistor—300 millivolts will drive both to cutoff. Collector and bias voltages are supplied through half-wave diode rectifiers from the control windings of the thyratron grid-control transformers.

Figure 4 shows the input circuit as it might be connected for constant-speed control of the motor. The calibrated speed-set potentiometer is supplied from a center-tapped transformer, which permits an adjustable amplitude, 0 deg or 180 deg phase reference signal to be added in series with the tachometer feedback voltage. 8he difference between the tachometer voltage and this reference voltage is the error signal applied to the transistor amplifiers.

The phase and amplitude of the error voltage determine the direction of rotation and speed of the servomotor with a certain torque. If the torque increases and the speed decreases, the tachometer voltage falls and the reference voltage takes command and speeds up the motor; if the torque decreases, the servomotor increases speed and the tachometer voltage takes command and brakes the servomotor to reduce the speed. In this manner the speed is kept constant, the actual speed setting being determined by the setting of the reference potentiometer.

The sensitivity of this system to ac error voltage may be increased if necessary by inserting a preamplifier, as shown in Figure 4. In general, three transistor preamplifiers have been used for this purpose: the error signal voltage is fed through an emitter follower, for impedance matching, to a grounded emitter amplifier, and then to another emitter follower for matching the transistor preamplifier to the power-amplifier transistor drive stages (Figure 7).

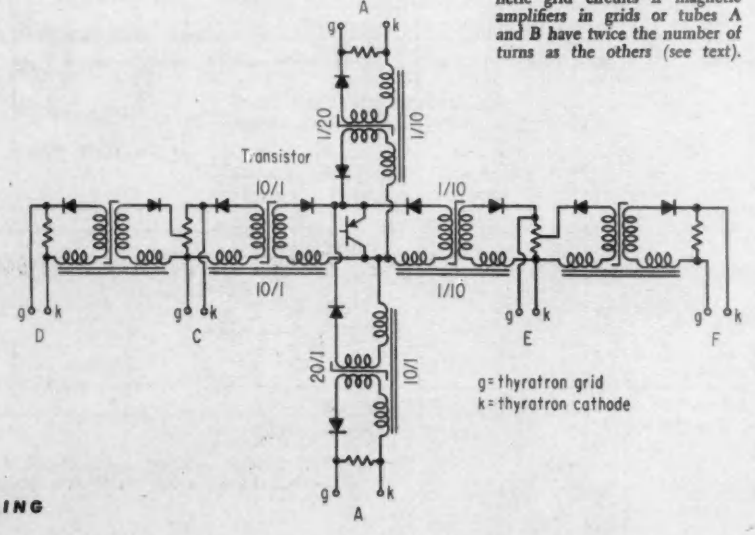
System performance

The speed vs. torque curves for a low-inertia, ½-hp, four-pole, 60-cps, two-phase servomotor are shown in Figure 8 for several constant-speed settings, and also for several constant error signals.

At the normal setting of the bias and gain controls, the locked-torque vs. error signal is quite linear, as shown by Figure 5. However, by a different setting of these controls, the relationship may be made to follow the square of the error signal.

The speed regulation shown in Figure 8 is tabu-

FIG. 6. Single transistor can be used to drive all six reset magnetic grid circuits if magnetic amplifiers in grids or tubes A and B have twice the number of turns as the others (see text).



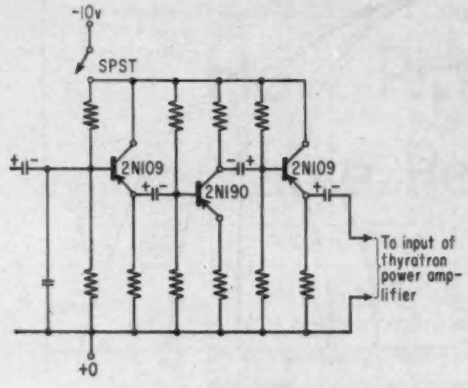
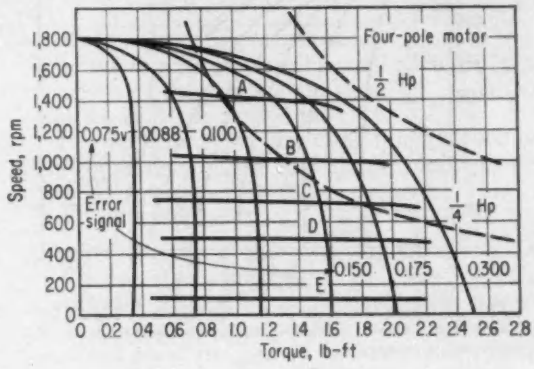


FIG. 7. Preamplifier used to increase sensitivity of thyratron controller.

FIG. 8. Flat curves (lettered) show regulation of new controller with four-pole ½-hp motor at five constant-speed settings. Other curves are speed vs. torque for constant-input-error voltages.



lated in the table below. No precision components or subsidiary feedback circuits were used to get these results.

Set rpm	Torque range, lb-ft	Rpm change
1,400	0.6 to 1.7	100
1,000	0.6 to 2.0	50
750	0.5 to 2.2	50
500	0.6 to 2.25	30
100	0.5 to 2.2	20

By using precision components with more complex preamplifier circuits, speed regulation in the order of tenths of a percent can be realized.

Horsepower at any point on these curves can be calculated from:

$$hp = \frac{\text{lb-ft} \times \text{rpm}}{5,250}$$

Figures 9 and 10 show the performance of a ½-hp, low-inertia, 60-cps, two-pole, two-phase servomotor—Figure 9 as connected directly to a two-phase line,

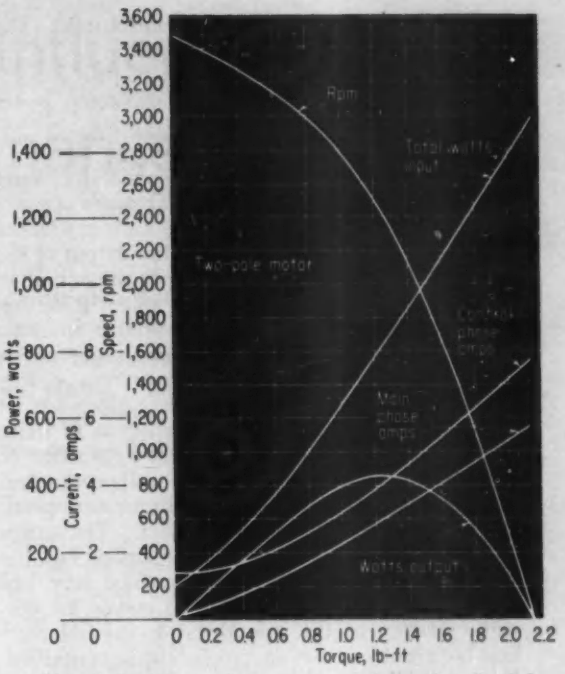


FIG. 9. Speed-torque for constant-error input plus electrical inputs and outputs for two-pole motor controlled directly from line. Compare Figure 10.

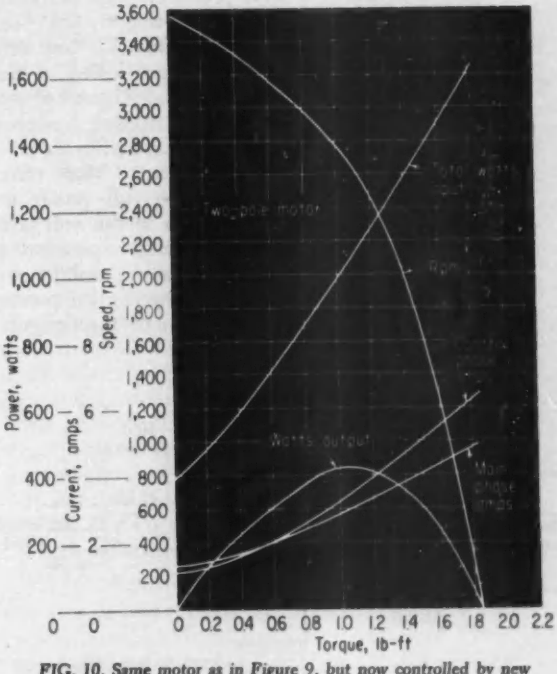


FIG. 10. Same motor as in Figure 9, but now controlled by new thyratron amplifier. Note high efficiency of amplifier (difference between input watts in Figures 9 and 10) under all load conditions.

and Figure 10 to the thyratron control unit. The main points to be compared are

- input power
- point on speed-torque curve of maximum power output
- locked torque readings

The difference between the total-watts input curves shows that the amplifier unit draws approximately 200 watts at standby and 330 watts at a locked torque of 1.84 lb-ft. At 2,500 rpm the output of the motor only is 0.572 hp; at 2,500 rpm the output of motor operating from the control unit is 0.562 hp, a loss of only about 2 percent.

Figure 11 shows a series of speed-torque curves taken using the same two-pole servomotor in Figures 9 and 10. The bias on the main phase was set so its thyratrons were fully conducting at all times regardless of the setting of the error signal; that is, only the control phase was proportionally controlled. Under these conditions the control unit was operating as a conventional servo amplifier. The curves are fairly linear with a large error signal, but the smaller amplitude error signals produce very bad cusps. Figure 12 shows the same curves for normal operation of the new thyratron control unit; here both motor phases are proportionally controlled. Note that all curves are substantially linear.

Position control

Figure 13 shows a servo-positioning circuit using two 10-turn potentiometers and a gear box used with the thyratron control amplifier for test purposes. Bias and gain controls were adjusted so that just enough power was supplied to both motor phases to hold the null position. When needed, however, the maximum power was instantly available for positioning under heavy-load conditions. Most other servo-positioning systems maintain full power on the main phase when the motor is in the null position. The accuracy of a high-power servo-positioning system using this thyratron servo-power amplifier and motor is limited only by the sensitivity of the preamplifier and feedback circuits chosen by the designer.

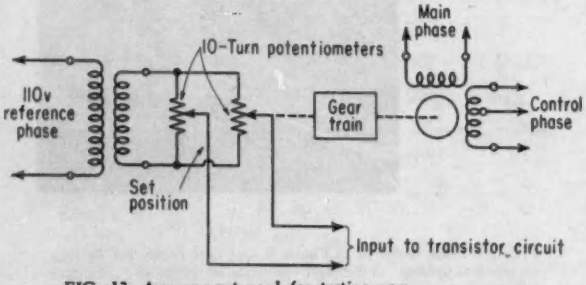


FIG. 13. Arrangement used for testing new circuit as position controller.

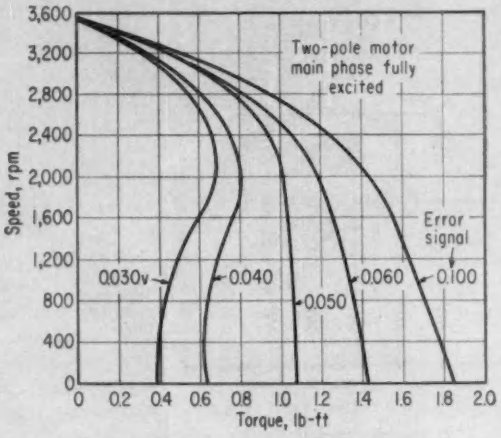


FIG. 11. Speed-torque family for constant-error inputs with one phase controlled, one phase fixed. Compare Figure 12.

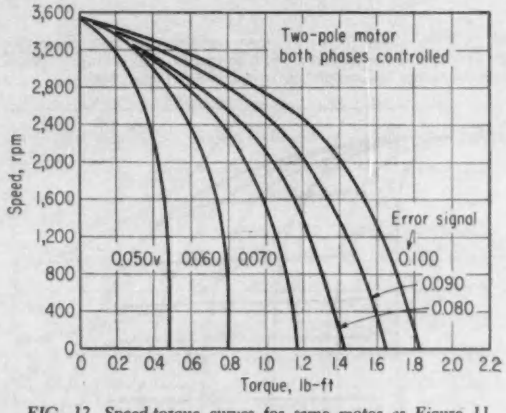


FIG. 12. Speed-torque curves for same motor as Figure 11 with both phases controlled by new amplifier. "Single phasing" is impossible.

System advantages

The new transistor-thyratron control system for the first time permits full utilization of high torque-to-inertia ac servomotors in the ⅛-to-3-hp range.

- The new circuit produces full motor voltage response in less than one-half cycle of the line voltage, compared to 4 or 5 cycles for the best magnetic amplifier circuits available.
- The circuit maintains an exact 90-deg relationship between motor-phase currents at all firing angles, thus producing maximum motor efficiency.
- One error signal linearly controls torque, although both reference and control phases are varied proportionally, which saves power under standby or null conditions.
- No "single-phasing" or motor overheating is possible, since both phases are controlled.

REFERENCE

1. *A MAGNETIC THYRATRON GRID CIRCUIT*, "Proceedings of the IRE", Vol. 44, No. 4, April 1956.

How Piping Influences Valve Performance

THE GIST: In his article on the selection of control valves (CtE, March '59, p. 103), author Valstar made a careful distinction between the characteristics of a valve and those of a valve-pipeline combination. To the systems designer, the latter characteristics are far more valuable, because most practical valve applications involve some piping. This article discusses the extent to which piping can alter the original valve characteristics and suggests how, in some cases, compensation can be built into the valve itself.

JAKE E. VALSTAR, C. F. Braun & Co.*

To provide a simple yet useful picture of valve behavior, this discussion will be limited to two rather widely used valve types: the so-called *linear* valve and the *equal percentage* valve.

For the linear valve, flow varies from 0 to 100 percent of maximum value in direct proportion to stem position, pressure drop being constant. This can be stated as a ratio: $F/F_{max} = S$ (1)

Ideally, there is no leakage in the closed position.

For the equal percentage valve, flow varies exponentially with a linear change in stem position. Here there must be some flow even in the closed position, since any change from zero to a certain flow would represent an infinite increase as a percentage. Manufacturers take advantage of this condition by treating valve leakage as this small initial flow. Depending on manufacturer and plug type, leakage varies somewhat. Assume, for the ideal valve, that this leakage or initial flow equals 2 percent of the maximum flow. Then flow will increase exponentially from 2 to 100 percent of its maximum value as the stem travels from 0 to 100 percent of its full stroke. Expressed as a ratio,

$$F/F_{max} = (0.02)\ (50^S) \quad (2)$$

where both F/F_{max} and S vary from 0 to 1.

Assume also that, for any fluid flow device, the relationship between flow and pressure drop can be stated as: $F = C\sqrt{\Delta P}$ or $\Delta P = (F/C)^2$ (3)

where F is the flow, ΔP the pressure drop, and C a constant flow coefficient or conductance factor.

Actually, C is not constant, but varies somewhat with changes in the Reynolds number. A quick look at the extent of this variation, however, proves the validity of the assumption. At Reynolds numbers above 10^5, variation of C is negligible. Even for an extremely bad case, where the Reynolds number might vary between 50,000 and 5,000 for flow varying between maximum and 10 percent, C drops only about 25 percent. This means that at 10 percent flow the pressure drop would have to be about 1.5 times what it would be if C were constant. Figure 1 shows that even this error can be neglected. Below 10 percent, as flow enters the laminar region, Equation 3 loses its validity entirely; but as long as this happens only over a small part of the total flow range, the errors are of no interest. They may be large as a percentage of the existing flow, but are negligible as a percentage of maximum flow. In cases where the flow is laminar over most of its range, Equation 3 cannot be used.

*Now with Hughes Aircraft Co.

The problem

In literature and in manufacturer's catalogs, control-valve capacity is generally expressed in terms of a C_v factor. This represents the constant in Equation 3 when the fluid is water at standard conditions. Under any other conditions, certain corrections should be made to improve accuracy of results. Although not generally accepted as such, the symbol C_v will be used here to signify the wide-open valve condition only. For any other valve position, capacity will be given as AC_V, where A varies between 0 and 1. For a linear valve then, A is proportional to stem position S. For an equal percentage valve, the relation is $A = (0.02)\ (50^S)$.

If another constant C_L is taken to represent a pipeline flow factor, general equations can be written for both valve and line:

$$F = AC_V\sqrt{\Delta P_V} \text{ and } F = C_l\sqrt{\Delta P_l} \quad (4), (5)$$

For a valve and pipeline connected in series, with a constant total pressure drop,

$$\Delta P_{tot} = \Delta P_v + \Delta P_l \quad (6)$$

The flow through the combination may be computed by solving for ΔP in Equations 4 and 5, adding

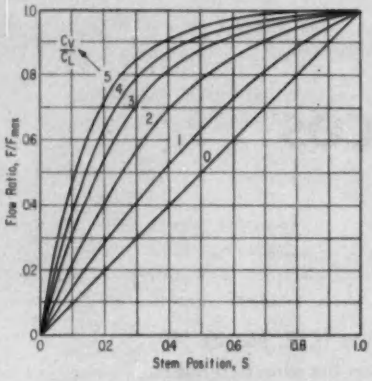


FIG. 1. Characteristics of line plus linear valve for different C_v/C_l ratios.

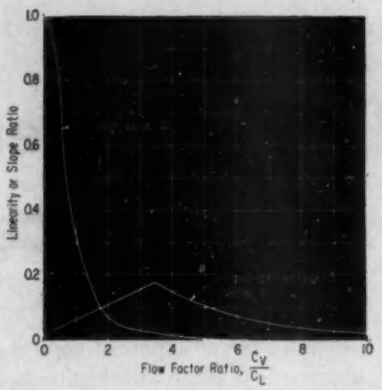


FIG. 2. Linearity of valve plus line combinations for both linear and equal-percentage valves.

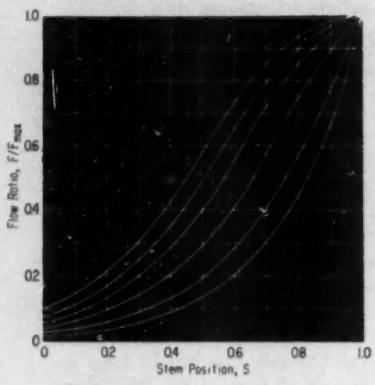


FIG. 3. Characteristics of line plus equal-percentage valve for different C_v/C_l ratios.

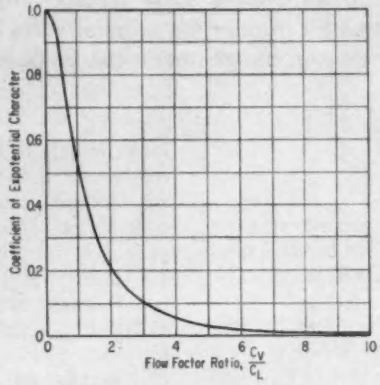


FIG. 4. Exponential character of line plus equal-percentage valve.

the result, as in Equation 6, and solving for F. Then

$$F = \sqrt{\frac{1}{(1/AC_v)^2 + (1/C_l)^2}}\sqrt{\Delta P_{tot}} \qquad (7)$$

$$\text{and } F_{max} = \sqrt{\frac{1}{(1/C_v)^2 + (1/C_l)^2}}\sqrt{\Delta P_{tot}}\,, \qquad (8)$$

Here F_{max} is the maximum flow which occurs when A equals 1. From these last two equations, the ratio expressed in Equations 1 and 2 for the valve alone can be rewritten for the combination as:

$$F/F_{max} = \sqrt{\frac{(C_v/C_l)^2 + 1}{(C_v/C_l)^2 + 1/A^2}} \qquad (9)$$

For a linear valve this equation actually gives the flow ratio as a function of stem position since, in this case, $A = S$. Figure 1 shows what happens to the linear valve plus line characteristic as piping is added, i.e., as the C_v/C_l ratio increases.

As it turns out, not much linearity exists above $C_v/C_l = 1$. To study this effect, let linearity be represented by the ratio of minimum to maximum slope for the curves in Figure 1. When the curve is a straight line, this ratio is unity. The more the curve bends, the smaller this ratio. Slopes can be determined either graphically or by differentiation. Curve A, Figure 2, shows a severe drop in the linearity of a linear valve plus pipe combination as the C_v/C_l ratio increases.

Figure 3 is similar to Figure 1, except that piping is combined with an equal-percentage valve rather than a linear valve. Note that at higher C_v/C_l ratios this combination actually offers more linearity than does the linear valve plus line arrangement. When slope ratios are computed for these curves, linearity can be plotted as curve B in Figure 2. This indicates that for higher C_v/C_l ratios an equal-percentage valve provides a more linear characteristic.

So far, both linear and equal-percentage valves have been considered from the point of view of desired linear characteristic. Where an equal-percentage characteristic is desired for the valve-pipe combination, the linear valve has nothing to offer.

Just as a measure of linearity was derived for the curves of Figure 1, a measure of the exponential character can be derived for the curves of Figure 3. Multiplying the slope of the curves by the F/F_{max} ratio yields a percentage variation. Compute minimum and maximum values of these percentage variations; their ratio then is an indication of the exponential or equal-percentage character. Figure 4 shows this particular character as a function of the flow factor ratio, C_v/C_l. Note the similarity between this curve and curve A in Figure 2. Again, a very small change in the C_v/C_l ratio sharply reduces the desired characteristic.

A possible remedy

The foregoing illustrates the effect of piping on valve performance. It shows that for C_v/C_l ratios above 1.0—those most frequently encountered in actual practice—very little remains of the original valve characteristic. One way to compensate this effect would be to design valve-plug characteristics for higher C_v/C_l ratios. Theoretically, at least, it is quite possible to design plugs so that the overall characteristic of valve plus line is linear or equal-percentage for any given C_v/C_l. Such an approach seems to be more urgently needed for the equal-

percentage characteristic than for the linear one.

At present, the C_v/C_l ratios for which the plug should be designed can only be estimated. Since it is impractical to design plugs for too many ratios, manufacturers would have to standardize on those most widely used. Present practice usually requires that valves be sized for one and a half times the normal flow at the normal pressure drop, where normal pressure drop is taken as one-third of the total system drop. This means that $(\Delta P_v/\Delta P_l)_{norm} = 0.5$. From Equations 4 and 5, it can be seen that for normal flow

$$AC_v/C_l = \sqrt{\Delta P_l/\Delta P_v} \qquad (10)$$

Since the right-hand term of this equation is the square root and reciprocal of the pressure-drop ratio mentioned above, $(AC_v/C_l)_{norm} = \sqrt{2} = 1.4$. Then if the valve is sized for a maximum flow of one and a half times the normal flow, $A = 1$ and $C_v/C_l = 2$. This seems to be a fairly good value. In practice, however, higher and lower figures are encountered, with a maximum of about 5. Of course, the correct way to find the best average value is to run a statistical evaluation of the various C_v/C_l ratios occurring in actual practice.

With the aid of Equation 9, the improved characteristics can be determined. For the valve plus line to be linear at $C_v/C_l = 2$,

$$F/F_{max} = S = \sqrt{\frac{5}{4+1/A^2}} \text{ or } A = \sqrt{\frac{1}{5/S^2-4}} \qquad (11), (12)$$

Using these same equations to determine an improved equal-percentage characteristic will yield

$$A = \sqrt{\frac{1}{2{,}504/(500.8)^S - 4}} \qquad (13)$$

Figure 5 shows the improved linear characteristic for various C_v/C_l ratios. The improved equal-percentage characteristic would look about the same if the flow-ratio scale were logarithmic and its origin modified to account for the initial leakage. Figure 6 compares the linearity of the improved characteristic with that of the system designed to be linear at $C_v/C_l = 0$. As can be seen, the new design is superior for C_v/C_l ratios between 1 and 4. The exponential-character curve for an improved equal-percentage valve would show a similar improvement.

SOME NOTES ON CALCULATING C-FACTORS

In the equation $F = C\sqrt{\Delta P}$, F represents the flow through the system; C, the conductance of the system; and ΔP, the driving force. This relation is analogous to Ohm's law in electrical engineering, except that Ohm's law is linear.

To make calculations for a system in which the components and their conductances are known, the flow must be measured in such a unit that the measure remains the same throughout the component. This means that theoretically the flow should be measured as weight or mass flow. For liquids, however, volume flow may be used when the specific gravity is fairly constant throughout the system. Otherwise, gpm "at standard conditions" should be used. For gases, volume flow "at standard conditions" is the accepted measure.

With flow measured in such units the total conductance of a system can be found from the conductances of its components. For components in series,

$$\frac{1}{C_t^2} = \frac{1}{C_1^2} + \frac{1}{C_2^2} + \ldots + \frac{1}{C_k^2}$$

and for components connected in parallel,

$$C_t = C_1 + C_2 + \ldots + C_k$$

where in both cases C_t represents total conductance.

Since flow must be expressed in weight or related units, the conductance-factor C must contain the corrections for specific gravity, pressure, and temperature. This means that the C_v-factor used throughout this article as a general conductance factor is not really constant for any given component, but depends on the flowing conditions, i.e., on the position of the component in the total system. The C_v as measured and given by the valve manufacturer is valid for one specific set of conditions only, usually for water at standard conditions.

Equations for determining the conductance factor C_l for a given pipe-line, as well as C-factors for fittings, orifices, etc., can be found in the fluid-flow literature.

If flow and pressure drop at normal conditions are known, the conductance may be expressed simply as

$$C = F/\sqrt{\Delta P}$$

This calculation is quite acceptable since variations in flow have a relatively small effect on the C-factor.

FIG. 5

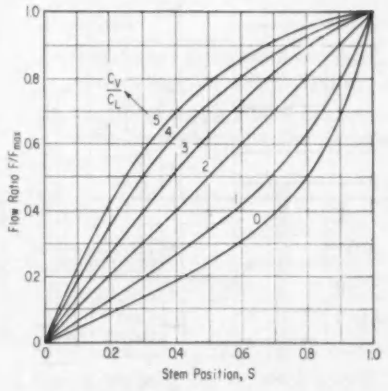


FIG. 6

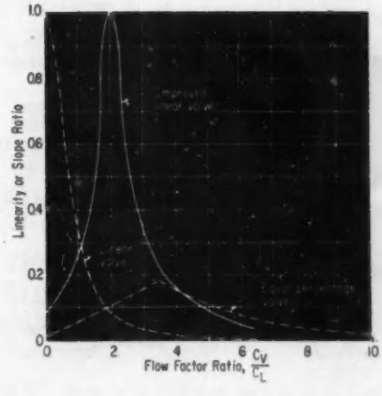


FIG. 5. Improved linear characteristic with plug designed for $C_v/C_l = 2$.

FIG. 6. Linearity of a valve designed for a higher C_v/C_l ratio.

Speeding Missile Trajectory Computation

The angular position resolvers used in the azimuth and elevation digitizers of this missile tracking system have errors of only one part in 200,000, and can be produced for linear motion measurements.

ERIC BURGESS
Telecomputing Corp.

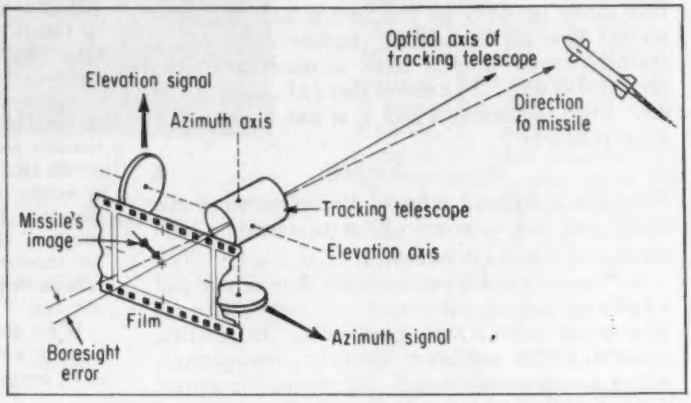


FIG. 1. Data from new resolvers on the azimuth and elevation axes of the tracking telescope are automatically digitized and passed to a computer.

Missile tracking systems generally triangulate the azimuth and elevation data from three radars, or from three optical cinetheodolites. Because of the large amount of such data collected during a single test firing, accurate calculation of trajectory must be done on high-speed digital computers. The angular data must therefore be digitized before it can be used.

With radar tracking, conventional methods of digitizing the elevation and azimuth are only accurate to 9 or 10 sec of arc; still, a digital output can be obtained immediately without having to go through the time-consuming process of film reading. The optical methods of the cinetheodolite, while usable only in clear weather, are inherently much more accurate. And a new automatic system can digitize the cinetheodolite's elevation and azimuth angles within 6 sec of arc.

The heart of the new system is a high-precision rotary transducer which converts angle into electrical phase difference. Electronic circuits then determine the position of the movable element of the transducer. The information is passed to a digitizer which indicates the angle electrically and visually, with an error of one part in 200,000. Then it is recorded or sent directly into a computer.

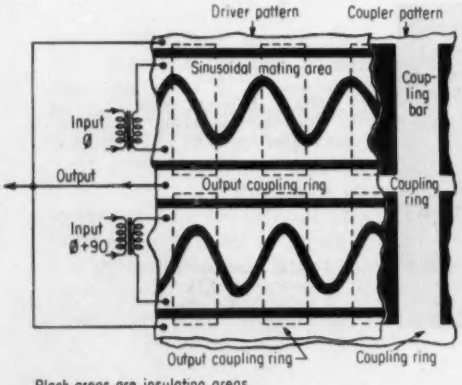
Calculation of the trajectory must also account for the boresight error (the difference in X and Y coordinates between some point on the missile and the optical axis of the tracker, see Figure 1), which is not digitized by this system. Since digitization of the boresight error still requires film processing and the use of semi-automatic optical reading instruments, the overall data reduction time for the best-accuracy trajectory is cut in half.

If a rough trajectory, neglecting boresight error, is satisfactory, it can be computed immediately for analysis of data telemetered from the missile, and a great time saving is possible.

The transducer

The transducer has two resolvers, one for coarse positioning and one for fine positioning. Both resolvers are deposited as patterns in metallic copper on a single pair of glass discs. A stationary disc contains the driver patterns, to which all electrical connections are made. The second disc is mounted on the shaft whose rotation is to be measured, and contains a

FIG. 2. Part of the patterns for the 200-pole-pair resolver, showing the displacement of the two sinusoid patterns and the relative size of the coupler patterns.



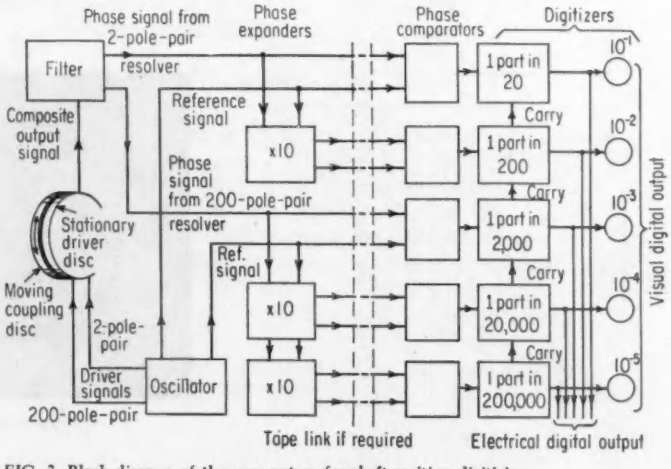
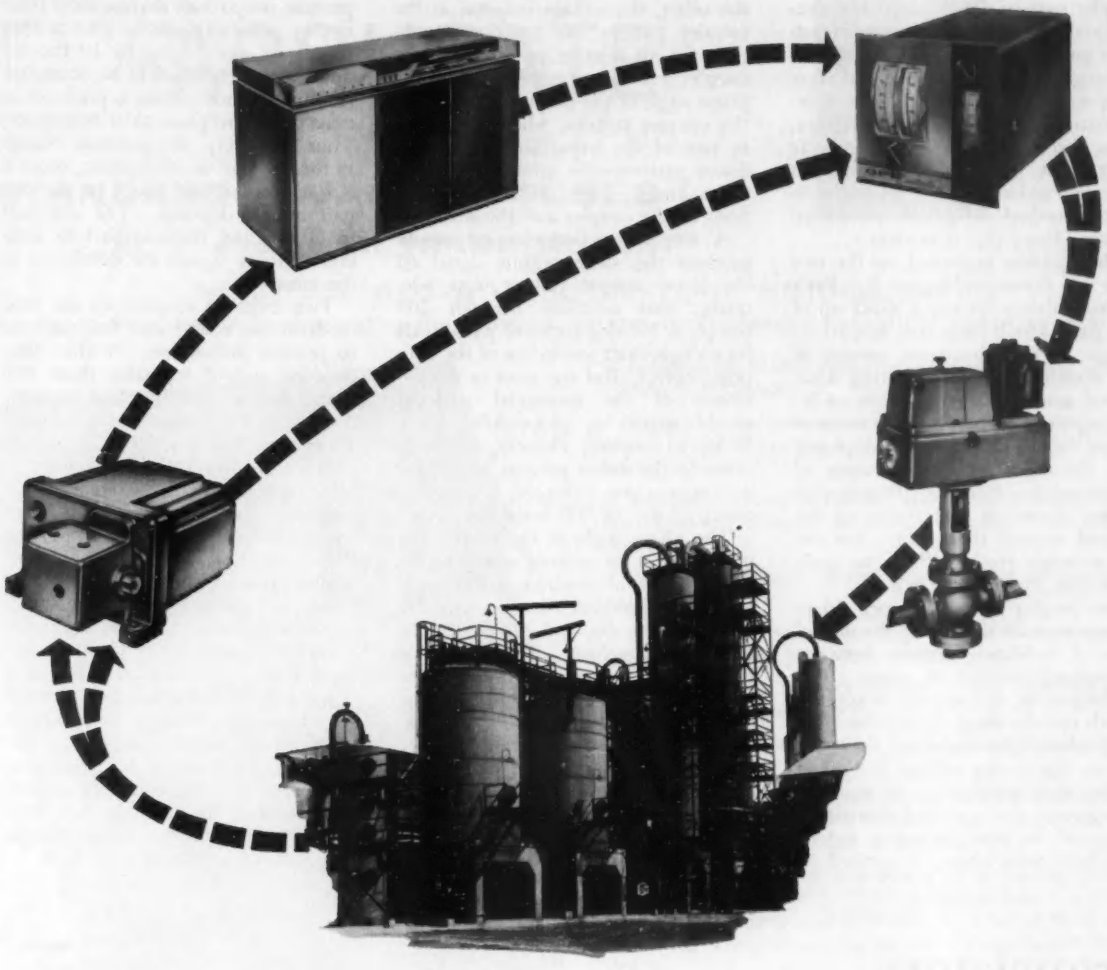


FIG. 3. Block diagram of the new system for shaft-position digitizing.



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coupler pattern which varies the electrostatic coupling between sets of patterns on the driver disc. Although the rotating coupler disc must be very close to the driver disc, there is no mechanical or electrical connection. Thus, no friction is added to the shaft to be measured. (The amount of inertia added depends on the resolution required — greater resolution meaning larger disc diameters.)

The patterns deposited on the two discs are shown in Figure 2. Each resolver's driver pattern is made up of four parts which form two subpattern groups. The subpatterns consist of two sinusoidally-shaped mating areas warped around a circle to leave an insulating sinusoid between the areas of copper. One subpattern is displaced from the other by a quarter-cycle of the sinusoid. For the 200-pole-pair resolver there are 200 cycles of the sinusoid around the circle. For the two pole-pair resolver there are only two cycles around the circle.

The coupler pattern for each driver pattern consists of rectangular-shaped areas of insulating surface between similar-sized conduction areas. The coupling areas, or bars, are connected at both ends by rings, so that the areas are all electrically common.

If an alternating voltage is applied to the first subpattern of sinusoid mating areas, and a second alternating voltage of the same frequency but in quadrature time phase, is applied to the other, the voltage induced in the coupler pattern has constant amplitude for all relative positions of the coupler and driver patterns. But the phase angle of the output voltage from the coupler pattern, when referenced to one of the input voltages to the driver patterns—the reference signal—varies linearly with the relative positions of the coupler and the driver.

A single coupling element would produce the same output signal (if the lower output voltage were adequate) that advances through 200 complete 360-deg cycles of phase shift for a single shaft revolution of the 200-pole resolver. But any error in the positions of the sinusoidal patterns would appear as phase-shift errors. With a coupling element for each cycle on the driver pattern, these random errors are averaged, permitting one part in 200,000 accuracy.

The phase angle of the output signal advances or retards according to the direction of rotation of the coupler disc. A phase detector receives the output of the disc and compares it to the reference phase. The output of the phase comparator drives a 10-position stepping type of cathode-ray-tube digitizer. By this means, one cycle of phase shift is resolved electronically into 10 parts, giving one part in 20 resolution per revolution of the two-pole-pair resolver, and one part in 2,000 for the 200-pole-pair resolvers.

Signals for driving the other digit position outputs are derived from these two by phase expansion. This is done simply by multiplying by 10 the frequency of each signal to be expanded. (Frequency multiplication produces an exact attendant phase-shift expansion.) Thus, for every step-position change in the one part in 20 digitizer, there is a 10-step position change in the one part in 200 digitizer. The one part in 20,000 and the one part in 200,000 digitizer signals are developed in the same way.

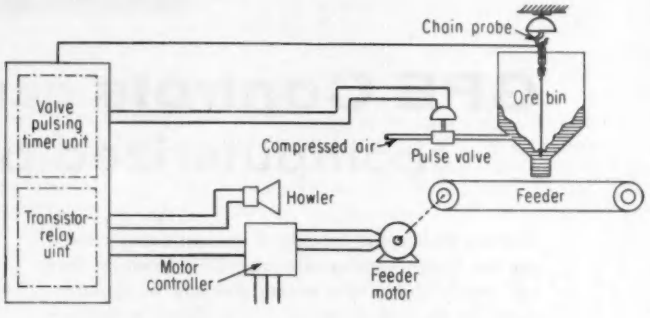
Two different frequencies are used to drive the coarse and fine patterns to prevent interaction. A filter after the disc output separates these two signals before expansion and comparison. The CRT digitizers produce a visual as well as an electrical output.

For some applications the electrical phase difference can be recorded on magnetic tape for later playback. Several recording stations along a proving range can feed information to one central playback and digitizing station. There the phase difference analog is digitized to make the trajectory data immediately available in visual or electrical form. Because the reference signal and the data signal are carried simultaneously through the system, the effects of distortion are minimized.

This system eliminates the time-consuming and error-susceptible process of reading the azimuth and elevation from film images, and accordingly cuts data reduction time in half.

Transistors Prevent Channeling in Ore Bins

C. M. MARQUARDT
Industrial Physics & Electronics Co.



A straightforward transistorized sensitive probe switch has recently found a number of successful applications in the ore-processing industry. One of these applications, at an Anaconda Co. plant, prevents the ore in bins feeding a conveyor belt from channeling and drawing a bin "dry" while there is still a lot of ore in the bin. Such hang-ups are quite frequent, and if ore builds up on the slopes of the bin until it breaks down naturally, the great cloud of dust produced raises dust levels far above safety limits and production must stop.

The system used to control this channeling hangs a chain probe directly over the bin outlet from the top, see diagram. Current in the probe is detected by a transistor amplifier circuit that holds a multi-pole relay closed as long as the chain contacts ore. The chain probe current is about 40 micro-amp maximum, and the probe supply is only 12.5 volts ac.

If the ore drops away from the chain, the relay drops out and energizes the valve-pulsing timer unit. The valve timer turns on air guns to pulse the bins with high-pressure air to break down the ore. The bin is pulsed for 3 sec every 15 sec. This generally breaks down the ore, and feeding then continues normally. But if the ore does not break down within 3 min, a howler is sounded to warn the operator. Then, if the operator does not free the ore within the next minute, the system automatically shuts down the conveyor belt. Twenty such systems will be used at Anaconda, where other probes will control bin levels and still others will shut down conveyors in case the chutes which they are feeding become plugged.

ACCURATE

μ, r_p, and g_m

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★ Meets requirements of IRE Standards for electron-tube testing.

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★ Measurements can be made from 270 to 400 cycles, or at 1000 cycles.

★ Tests can be made with self-biasing resistors in the circuit. In twin-section tubes, panel switch connects resistor to each cathode or to both cathodes in parallel.

★ Panel switch permits selection of a 10,000-ohm or 100,000-ohm standard. Lower resistance standard improves sensitivity of balance and S/N ratio by a factor of 10 when measuring low-plate-resistance or high-transconductance devices.

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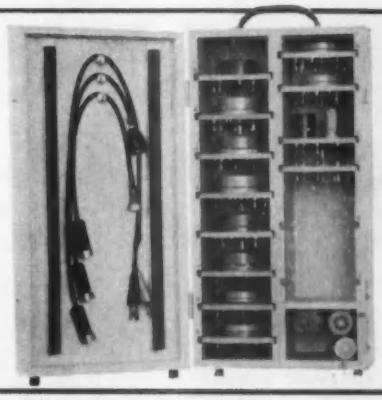
Type 1951-E Filter . . . for use at either 270 or 1000 cycles . . . useful for reducing background noise when making balances . . . $80

Type 1212-A Unit Null Detector . . . for measurements from 20c to 5 Mc . . . 40 μv at 1 kc gives 1% meter deflection . . . $145. (1203-B Unit Power Supply required . . . $40.)

Accuracy: ±2% where r_p is between 1 kilohm and 1 megohm. The expression $\mu = g_m r_p$ will check to ±2%. At lower and higher values of r_p, error increases slightly.

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Novel Circuits Simplify Alternator Control

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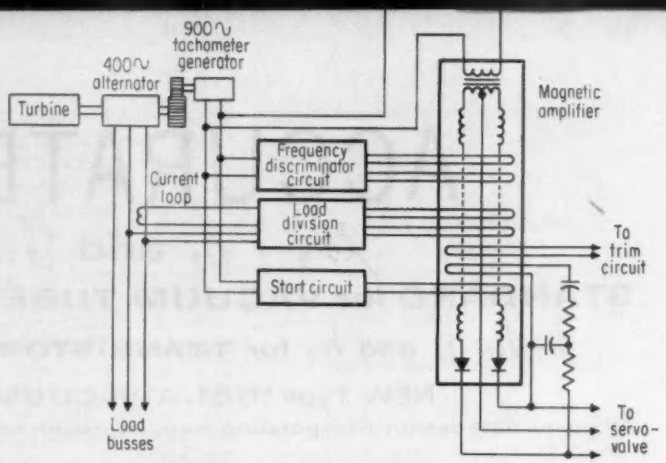


FIG. 1. Mag-amp controller handles alternator frequency and load division between alternators. Blocked circuits contain only transformers and RC networks.

The high sensitivity and reliability requirements of complex electronic systems in modern aircraft and missiles are decreasing the permissible frequency error and load unbalance in associated power supplies. Since this is a servo problem, power supply alternators are driven by servo-controlled prime movers. In the General Electric Model AD-10D2 turbo-alternator drive, for example, an electrohydraulic servovalve controls a piston-actuated flow-control valve that throttles air to the drive turbine.

The control system for this three-phase 400-cps supply must maintain the frequency constant within a few percent, in spite of main-engine speed changes and variable electric loads. It must also distribute the load evenly among alternators when they are operating in parallel. A magnetic amplifier controller, Figure 1, that meets these requirements includes several interesting circuit solutions that permit the compact packaging in Figure 2.

Frequency control

A 900-cps tachometer generator geared to the alternator provides a signal proportional to turbine speed, and hence to line frequency. The higher frequency of the tachometer gives greater sensitivity to variations in speed than would be possible at 400-cps with the unique and very simple frequency discriminator used. This discriminator is merely two notch-type filters staggered-tuned about 900 cps with their outputs subtracted, see Figure 3. The algebraic addition of the notch filter (parallel-TRC network) outputs is done in a control winding of the magnetic amplifiers, and the control current becomes positive or negative as the tachometer frequency goes above or below 900 cps. At 900 cps the control current is zero. The magnetic amplifier, in turn, controls the servovalve, and hence the turbine speed, to bring the tachometer frequency back to 900 cps and the control current to zero.

Load division control

The load-division-error circuit is a balanced demodulator or phase-detector that functions only when its alternator is in parallel with other alternators. The reference signal is taken from one phase of the 400 cps alternator output. The modulating signal is obtained from current transformers whose primaries are connected to the reference phase of their respective alternators, and whose secondaries are connected in a series loop. The secondary of each current transformer also feeds the center leg of the balanced demodulator circuit. The demodulating action then gives an output current proportional to the real alternator current difference being supplied. Since the terminal voltages are constant, and since the phase loads are balanced, the real alternator current difference is proportional to the load division error. This output current is fed to a control winding in the magnetic amplifier, which, through the servovalve, increases or decreases the input energy to the drive to reduce load division error.

The starting circuit controls automatic start of the turbo-alternator drive. It applies a current to one of the control windings during start to oppose the normal signal derived from the frequency reference, since the unit is underspeed. A resistor-capacitor network slowly "washes out" the start circuit current, and the drive speed increases until the frequency discriminator takes over and controls the servovalve for the desired regulation action.

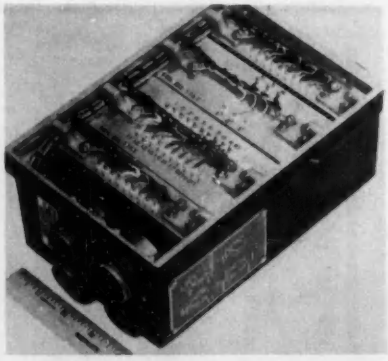


FIG. 2. All components except the tachometer generator are encapsulated in the four modules which are the four heavy blocks in Figure 1.

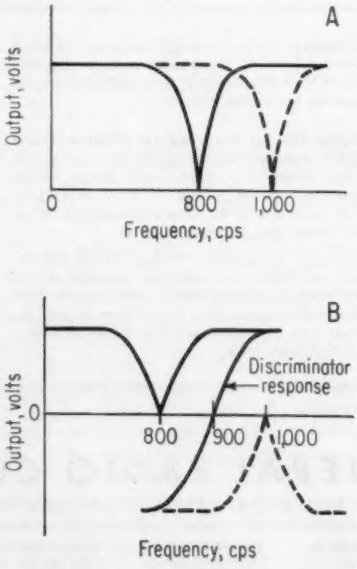


FIG. 3. A—Amplitude-frequency characteristics of RC parallel-T networks. B—Subtracted outputs of two networks in A produce discriminator characteristic.

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Digital Building Blocks Form Go/No-Go Timers

J. MITCHELL and G. L. KING,
Packard Bell Electronics

During qualification testing of ground support equipment for the THOR missile, the Packard Bell Missile Equipment Section was faced with requirements for measuring times varying from milliseconds to a quarter-hour. Measurement accuracy was required to be 1 percent or better over all time ranges. The conventional solution was to use high-speed recorders for the short-time durations and a clock-timer, or a combination of the two, for the long durations. However, since the equipment was to be used for high-rate production-line testing, a direct go/no-go readout was required and operator judgment had to be eliminated from results. A market check uncovered no suitable timer.

A digital timer designed and assembled from shelf-item computer "building blocks" contained the requisite characteristics for tests in the millisecond-to-quarter-hour category and could be varied in size or capability by the plug-in method. The timer measures in 2-millisec increments with a 1-percent accuracy in its present configuration. Accuracy of 1 percent and reduction of the measuring increment to 20 microsec may be obtained by varying the clock frequency. Any type of timer can be made up in a like manner. The timer shown in Figure 1 is designed to test the closing and opening of time-delay relays which have tolerances of plus or minus 10 percent. Therefore it sets go/no-go limits to plus or minus 10 percent the nominal delay time. The limits are established to 1-perment accuracies.

The time delay relay to be tested is connected electrically as shown in Figure 1, and the selector switch is

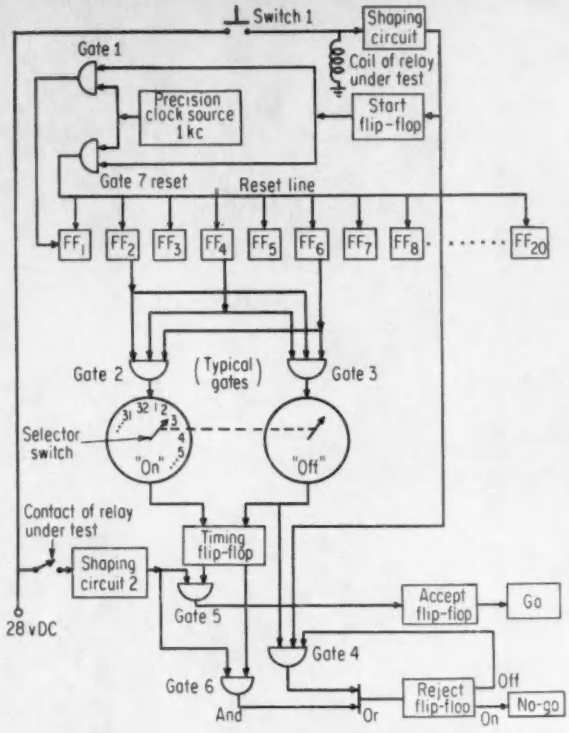


FIG. 1. Block diagram of go/no-go timer for production testing of time-delay relays. The selector switches actually determine flip-flop connections to gates 2 and 3, and are drawn as shown to simplify diagram. Relay under test must close while timing flip-flop is ON.

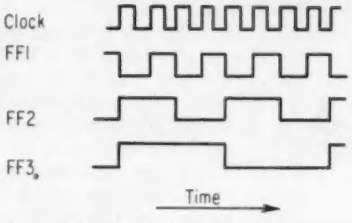


FIG. 2. Time relationships between clock source and flip-flop outputs.

turned to the position corresponding with relay model number. Switch 1 is closed and the test begins. Switch 1 triggers the start flip-flop ON, which sends a pulse enabling gate 1 and allows clock pulses through gate 1 to the binary counter flip-flop.

The counter flip-flops are activated sequentially—*FF1* activates *FF2*, which activates *FF3*, which activates *FF4*, etc. Figure 2 shows the time relationship between the clock and the counter flip-flop outputs. Each change of state of *FF1* occurs on a negative-to-positive transition of the clock and is, therefore, one-half clock speed. Each subsequent flip-flop is also one-half the speed of its predecessor. The proper gates are selected by the selector switch, which connects the counter flip-flops to them and to the timing flip-flop. When the counter flip-flops reach the state corresponding to the selected gate, the gate is enabled.

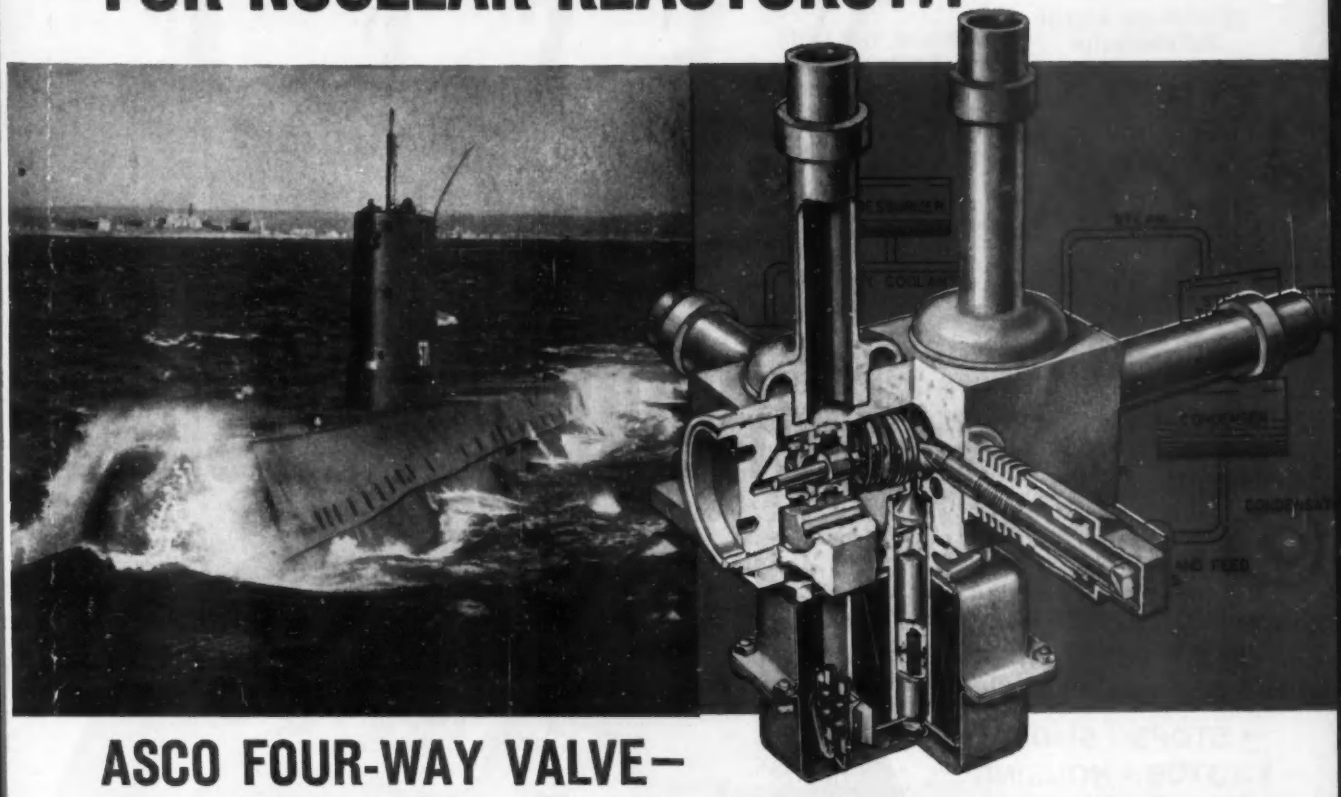
Gate 2 is enabled first (at minus 10 percent of nominal time delay for the relay under test). When it goes on, it triggers the timing *FF* ON. The counter continues counting and when the plus 10 percent value is reached for gate 3, the timing flip-flop is triggered OFF.

The contact of the relay must close during the interval that the timing flip-flop is ON to obtain a GO indication. This is determined by gate 5. This AND gate operates only if the timing flip-flop and shaping cirsuit 2 are ON at the same time.

If the relay contact closes prior to the timing flip-flop limits, the NO-GO indication is triggered ON by gate 6. This gate is enabled if there is no signal from the timing flip-flop at the moment the signal arrives from shaping circuit 2.

When the relay contact closes after the timing flip-flop limit is complete, the timing flip-flop has already been triggered OFF by the counter flip-flops. In this case, gate 4 is enabled by gate 3, by the start flip-flop, by the timing flip-flop not being ON, and by the fact that NO-GO is not already ON. The reject signal, therefore, is presented at the same time the timing flip-flop is triggered OFF and NO-GO is indicated.

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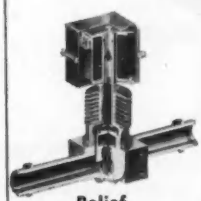
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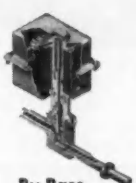
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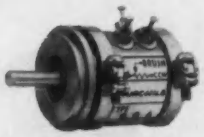
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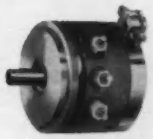
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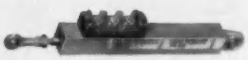
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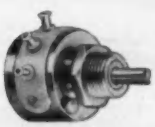
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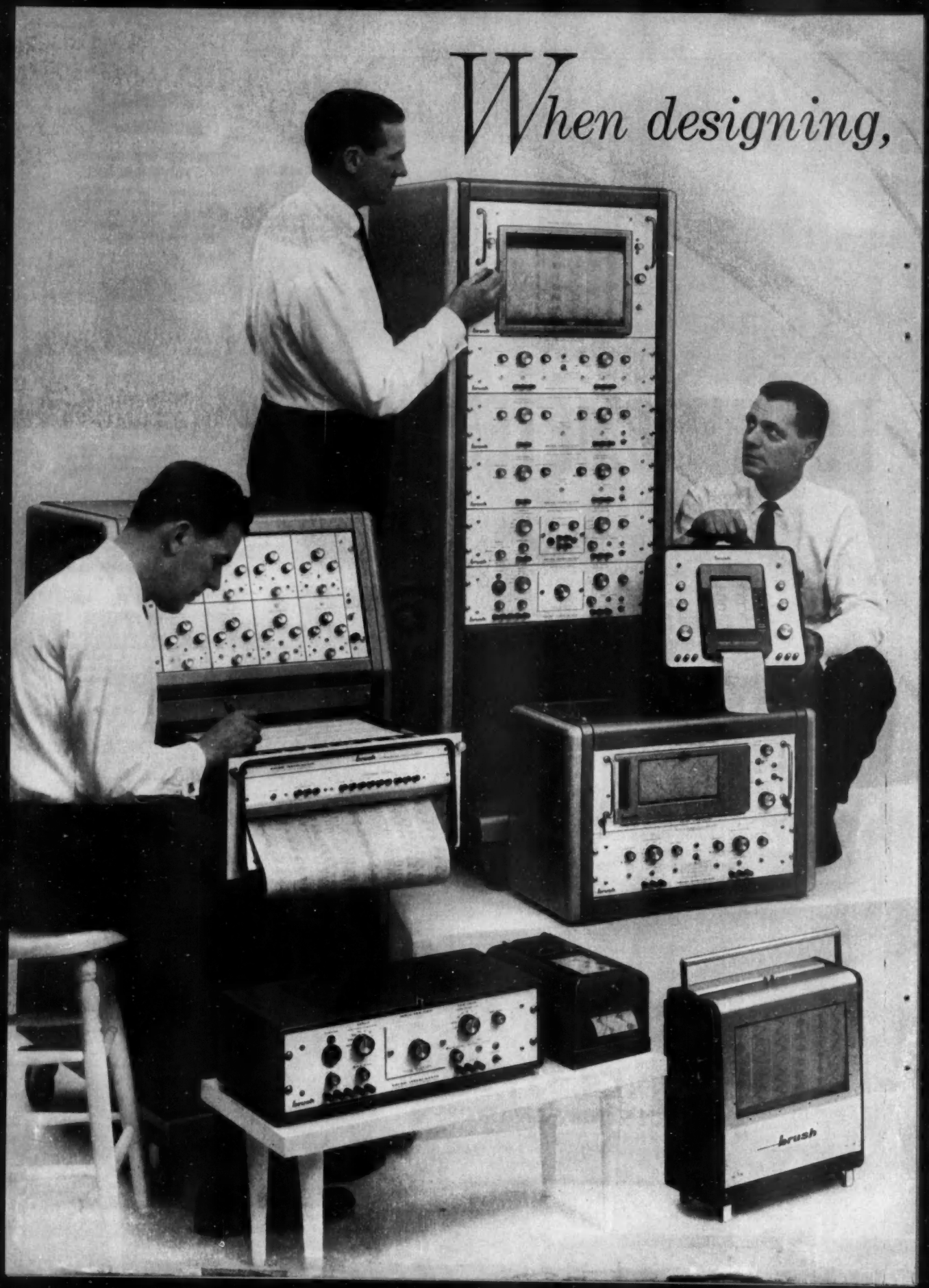
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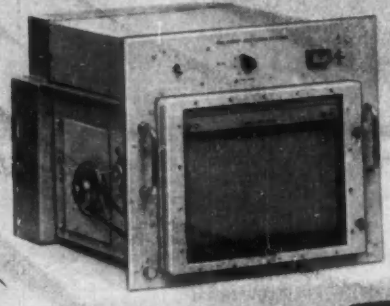
All Brush Recording Systems reflect advanced concepts in design that mean exceptional versatility, accuracy and reliability in your data collecting operations.

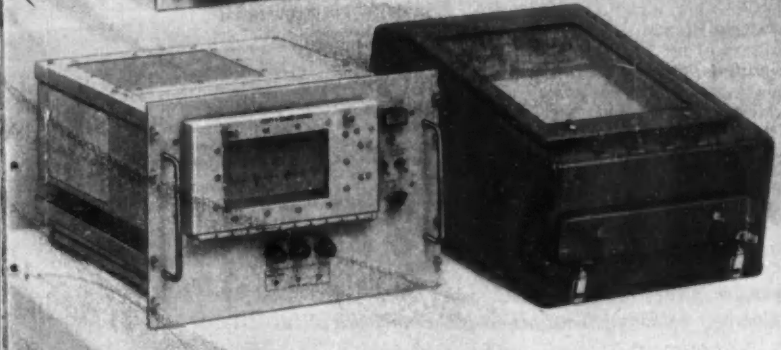
Your most exacting requirements can be met by these *direct writing* systems whether military or industrial. They display information *instantly*—give you precise data for quick decisions. You control the data you need, exclude the extraneous, and have optimum flexibility for future applications not yet contemplated.

Widest choice of equipment in the industry. Ink, electric or thermal writing . . . curvilinear or rectilinear readout . . . horizontal or vertical presentation . . . chart speeds from 10 inches/day to 4 feet/second . . . complete selection of amplifiers . . . rack mounted, bench top or portable configurations.

A pioneer in instrumentation since 1930, Brush has always built for ruggedness and precision. Installations are right. Operating manuals contain clearly written instructions. Your personnel are trained properly.

In designing, testing or monitoring you can get better results from Brush *Ultralinear* Recording Systems. Let's talk it over. Set a date. We'll be there.





Write for free informative booklet, "New Concepts in Recording." Contains helpful ideas and suggestions.



brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

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Factory branches, service and warehousing at Arlington, Va., Boston, Cleveland, Los Angeles, San Francisco and Seattle; engineering representatives in all key locations.

BOILING HEAT

...or



FREEZING COLD

...Hold it Constant with RCA Thermoelectric Junctions!



RCA offers new solid-state device capable of maintaining constant control of "zone" temperature below or above ambient.

Holding a "zone" at a constant temperature...*despite wide variations in ambient*...often demands heating or cooling systems that are complex. Usually a compromise is employed, resulting in controlling temperature at a point *above* ambient. To hold temperature *below* ambient requires refrigerants, ice packs, or forced liquid cooling. These techniques have inherent limitations.

Now, RCA announces developmental Thermoelectric Elements...unique and extremely compact devices capable of producing "boiling heat" or "freezing cold" in small "zones". Circuitry is simple. You have infinite control from maximum cooling to maximum heating through variations of the dc power supplied to one device. With no moving parts, vibration is eliminated—long life assured.

RCA Thermoelectric Junctions are excellent for service in laboratory "ovens" or "cold chambers". The new elements make practicable, for the first time, the manufacture of simple and completely transportable temperature-control apparatus capable of holding temperatures constant *below* ambient.

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HUmboldt 5-3900

NORTHEAST
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Hillcrest 4-7200

EAST CENTRAL
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CENTRAL
Suite 1154, Merchandise Mart Plaza
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GOVERNMENT
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BAldwin 6-2366

1625 "K" Street, N.W., Washington, D.C.
District 7-1260

For information on developmental samples, please contact the RCA sales office nearest you, or, write direct to RCA Commercial Eng., SectionD-56-NN,Somerville, N. J.

RADIO CORPORATION OF AMERICA
Semiconductor & Materials Division
Somerville, N. J.

Depreciation Reform—

Why Industry Needs A Modern Tax Policy

A shockingly large proportion of our industrial plant and equipment is obsolete. As indicated by an earlier editorial in this series, over $95 billion would have to be spent —and spent soon—to bring our industrial facilities up to the best modern standards. Yet plans for 1959 call for little more than $30 billion of actual spending—barely enough to make a start on this backlog of modernization.

At the heart of the problem of obsolescence is a federal tax policy that discourages business from replacing inefficient facilities. It is the purpose of this editorial to spell out a tax reform Congress can make this year—with little cost in terms of tax revenue—that would go a long way toward removing the barrier to modernization of plant and equipment. This reform is a more realistic system of tax deductions for depreciation and obsolescence of productive facilities.

A Barrier to Modernization

Industry abounds with examples of old and obsolete facilities—despite large expenditures made in the past few years. Two-thirds of our metalworking equipment is over ten years old. Over half the capacity of our chemical process industries was installed before December 1950. Only a minor fraction of our railroad freight moves in new freight cars or the new push-button freight yards.

The tax law bears a large part of the responsibility for this lag in modernization because of its important influence on business investment in plant and equipment. For many years the tax law has permitted as a deduction from income "a reasonable allowance" for wear and tear and obsolescence of productive facilities. These annual deductions affect business investment in several ways.

- They are the way a company recovers its investment in plant and equipment.
- They determine in large measure, the amounts of money that are spent each year to replace and modernize facilities.
- Furthermore, the schedule for depreciation often determines **when** a specific machine or building is actually replaced.

The law requires that depreciation deductions be spread over the "useful life" of a building or machine. But the periods of useful life for tax purposes today still depend heavily upon tables drawn up by the Treasury almost 20 years ago. These tables reflect the replacement practices of depression years. Also, they were compiled at a time when the pace of technological progress in industry was much slower than it is now. **For nearly all types of equipment the indicated period of useful life is longer —sometimes much longer—than most experts consider realistic at today's rate of technological advance.**

The result of these outmoded depreciation schedules is that the recovery of investment is dragged out, and the replacement of obsolete equipment is delayed.

In The Right Direction

Congress should establish, by law, the right to use shorter depreciation periods on productive equipment. It should do so in a way that would free industry from obsolete concepts of the rate of technological change and would provide incentives to install new equipment and produce new products.

The tax reform act of 1954 made some progress in this direction—but not enough. It introduced new methods for calculating depreciation —the declining balance and the sum-of-the-years' digits—which enable a business to recover most of the investment in a new facility in the early years of its useful life. However, these new methods do not accomplish their desired purpose when the supposed "useful life" is still an unrealistically long period of years.

Industry is by no means free from blame for the failure to bring depreciation policy into line with the needs of a modern, growing economy. According to Joel Barlow, president of the Tax Institute, "management has largely ignored the Commissioner's invitation . . . to come into the Internal Revenue Service office and make a case for shorter depreciable lives by establishing technological obsolescence."

The failure of many companies to see their own interest in more realistic depreciation not only holds them back from modernizing their own facilities but also lends support to the Treasury in its continued adherence to an outdated policy.

A Suggestion For Reform

An excellent model for reform of the depreciation policy in our tax law is the system used successfully in Canada for a decade. In Canada, all productive equipment may be depreciated at relatively fast rates assigned to each of 14 broad categories. The Canadian system permits depreciation up to twice as fast as the antiquated tables of useful lives now followed in the U. S. It also gives the individual business far greater flexibility in determining depreciation schedules that fit its own needs and experience.

For example, in the category or "bracket" covering general machinery a taxpayer in Canada may depreciate up to 20% of the machine's value annually, on a declining balance basis. In the U. S. the fastest rate at which many types of machinery can be depreciated is only 10%. In other categories, from tools and dies to buildings and pipelines, the Canadian system also allows faster depreciation and provides greater incentive to invest in new facilities.

The cost of this reform in terms of lower tax revenue would be small—probably less than $500 million in the first year. And even this would merely be postponed, not permanently lost. Indeed, there is a very good prospect that tax revenue would not suffer at all. The increase in spending for new plant and equipment resulting from this tax reform would mean an increase in wages and profits—and therefore in taxes—in industries that produce machinery and other capital goods.

A realistic tax policy on depreciation would provide a badly needed incentive for industry to replace obsolete and inefficient facilities with up-to-date plants and equipment. It would step up our rate of technical advance and economic progress. And it would put U. S. industry in better shape to meet the growing competition from other countries that have grasped the advantages of fully modern technology.

This message was prepared by the McGraw-Hill Department of Economics as part of our company-wide effort to report on opportunities for modernization in industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

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Replace your awkward, obsolete needle valves!



NOW— ON-OFF at 3000 PSI with new quarter-turn FLO·BALL plug valve

. . . priced no higher than needle valves!

Hydromatics Series 715 Spherical Plug Valve breaks through 150 PSI limitation of ordinary plug valves!

- **LOW TORQUE, EASY ACTION**... Quarter-turn operation, requiring only 4 lb-in torque at 3000 PSI.
- **MAXIMUM FLOW EFFICIENCY**... Straight-thru FLO·BALL design has more than twice the flow of needle valves.
- **POSITIVE ON-OFF INDICATION**... The large, arrow-shaped handle shows valve position at a glance.
- **ZERO LEAKAGE**... Mass Spectrometer tests with Helium prove zero leakage.
- **UNIVERSAL MOUNTING**... Can be panel, side, bottom or line mounted.
- **REMOVABLE FLANGES**... Replace damaged flanges in seconds—no need to scrap entire valve.
- **VERSATILE SERVICE**... Leak-proof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol and many other media.

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Size	Part No.	Size	Part No.
1/8	715A1	1/4	715A2
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NOTE — Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

ALL STAINLESS STEEL CONSTRUCTION — COST NO MORE THAN OLD FASHIONED SCREW-TYPE VALVES!

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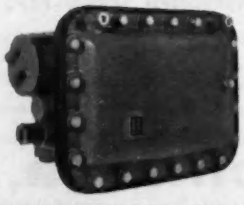
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CIRCLE 82 ON READER-SERVICE CARD





RELAY RACK MOUNTING permits four transducers to be mounted abreast on a standard 19-inch-wide relay rack with 7-inch vertical spacing.



EXPLOSION-PROOF HOUSING meets conditions of operation specified under Class I, Group D, Division 1 of the National Electrical Code.

WEATHERPROOF HOUSING is diecast aluminum, dust-tight, splash-proof, for indoor or outdoor mounting. Supplied with vertical surface mounting accessories. Valve or pipe mounting bracket accessories available. This housing meets Class I, Group D, Division 2 requirements of the National Electrical Code.

	P/I TRANSDUCER	I/P TRANSDUCER
Input	3-15 psi	4-20 ma d-c
Output	4-20 ma d-c	3-15 psi
Accuracy	±¼% of span	±¼% of span
Ambient temperature range	−40° to +150°F	−40° to +150°F
Maximum load resistance	800 ohms	————
Supply	42 ±2 V d-c	20 psi
Air Consumption	————	less than 0.35 cfm

adapt your pneumatic loops to centralized, electric control with *ElectriK Tel-O-Set** TRANSDUCERS

Now, get the desirable advantages of electric control with your present *pneumatic* instruments. New *ElectriK Tel-O-Set* transducers let you make use of modern data processing techniques . . . centralize multi-plant control . . . and bring additional facilities into your control system.

The P/I (pressure-to-current) transducer converts the standard 3-15 psi signal of your present pneumatic instruments to a standard electric signal which is fed to the electric control center. Its counterpart, the I/P (current-to-pressure) transducer, converts the signal from the electric control center back to the standard 3-15 psi signal which is fed to the pneumatic control loop. Used together with your present pneumatic instruments, they permit long-distance, high-speed electric transmission of process variables, eliminating the lags characteristic of extremely long runs of pneumatic tubing.

These twins have a calibrated accuracy of ± ¼% of span. They're completely transistorized for long, reliable service. Only two wires, forming a series circuit between transducer and receiver, are needed to carry the signal and line power is not required in the field. Both units are trim, compact, and easily installed, adjusted and maintained.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

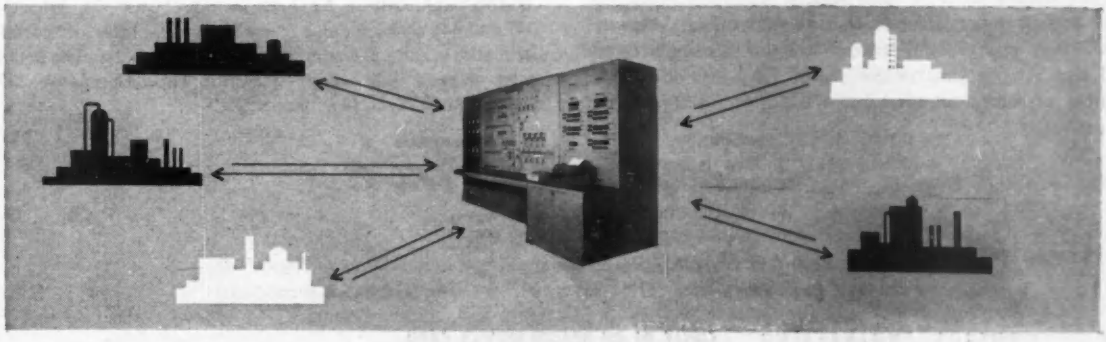
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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Honeywell

H HONEYWELL *First in Control*

Diagram symbolizes use of transducers in a "wheel-type" plant to convert signals from existing pneumatic instruments to electric signals for data processing or electric control. White silhouettes represent future plants.



CIRCLE 83 ON READER-SERVICE CARD

Tubexperience in action



Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

Up to 3000 ft. of capillary tubing in 1 piece

Seldom does an instrument installation require 3000 ft. of capillary tubing in one piece—the quantity is normally much less. But the advantages of long lengths are numerous. A simple long length of capillary tubing has greater ID uniformity than a series of short lengths separately produced. This permits more accurate transmission of data between instruments controlling a process. Instrument manufacturers find that long lengths reduce scrap. They also lessen the number of setups required and the costs of inserting the capillary tubing in flexible metallic protective sheathing.

Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to 3/16 in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details —let us send you a copy. Superior Tube Company, 2026 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 3/8 in. OD—certain analyses in light walls up to 2½ in. OD.

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

NEW PRODUCTS

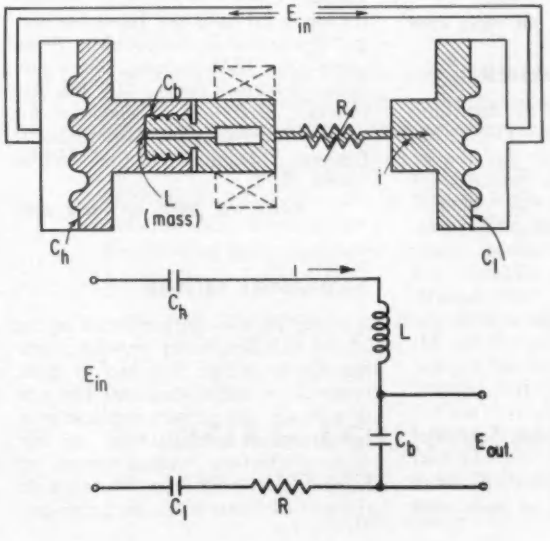
NEW FLOW TRANSMITTER
uses differential transformer.

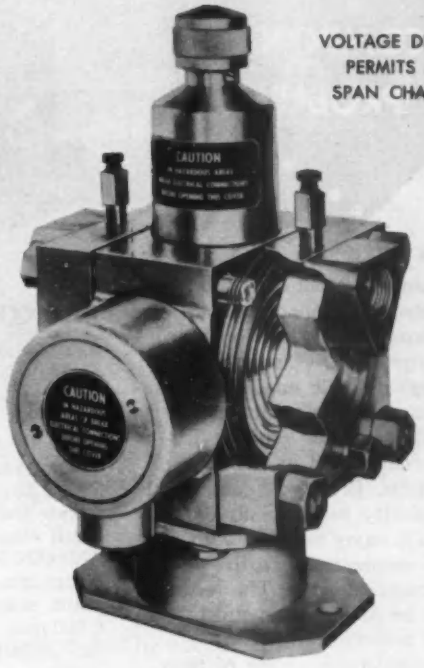
Developed for use with Taylor's all-electronic process control system (see CtE Special Report, November 1958, pp 81-96), this new differential-pressure transmitter combines hydraulic amplification of the input signal with a linear differential transformer output.

The schematic diagram below, along with an electrical analogy of the unit, illustrates its operation. When a differential pressure, E_{in}, is applied, some of the filling liquid behind the high-pressure diaphragm enters the smaller-diameter bellows chamber. Because of the area difference, a given volumetric displacement produces a bellows movement that is considerably larger than the movement of the diaphragm. This represents hydraulic amplification of the input. At the same time liquid behind the bellows moves into the cavity behind the low-pressure diaphragm.

A stem attached to the bellows carries the core of a linear differential transformer. Any motion of the bellows then produces axial motion of the core within a hollow, nonmagnetic tube. A casing mounted on the outside of this tube carries the transformer windings, and can be positioned along the tube to adjust the instrument zero. A variable potentiometer placed across the transformer output provides for a 4-to-1-span adjustment.

Damping of the instrument can also be adjusted by means of a variable-flow restriction in one of the liquid passages. This is shown as R in the diagram below. Rubber O-rings mounted on the bellows shaft provide overrange protection. They act as positive shutoff valves in case of excessive deflection in either direction.





VOLTAGE DIVIDER PERMITS 4-1 SPAN CHANGE

Another interesting feature of the instrument's design concerns the technique used for temperature compensation. Since temperature changes produce changes in the span of the instrument and would ordinarily cause an error in the instrument output, manganin wire is used in the span adjustment potentiometer. When the resistance of this wire is carefully matched to the resistance of the copper transformer windings, span compensation results.

To reduce eddy current losses in the differential transformer, both the core stem and the coil tube are made of annealed-type 302 stainless steel.

Characteristics:

Span: 50 to 200 in. water differential, continuously adjustable
Accuracy: within 1 percent
Static pressure rating: 1,500 psi
Overrange pressure: 1,500 psi either side
Damping: internal, continuously adjustable
Volumetric displacement: 0.025 cu in. at 100 in. water differential
Transformer input: 100 ma at 60 cps
Transformer output: 0 to 200 mv at 60 cps
Ambient temperature range: minus 20 to plus 200 deg F
Shock and vibration: 1-g acceleration, 0 to 60 cps
—Taylor Instrument Cos., Rochester, N. Y.

Circle No. 200 on reply card

RELIABILITY... THE SOLUTION TO YOUR ELECTRONIC COMPONENT PROBLEMS

Designing reliability into electronic components and instrumentation is Borg Equipment Division's business. Borg's reliable engineering, research and production facilities are at your service for commercial or military projects. Bring your component reliability problems to Borg. You'll enjoy working with our cooperative, creative engineering staff. The result will be a sound, practical and reliable solution at a considerable saving of time and money. Here are just a few of the products manufactured by Borg . . .

- FREQUENCY STANDARDS
- AIRCRAFT INSTRUMENTS
- POTENTIOMETERS
- MULTI-TURN COUNTING DIALS
- FRACTIONAL H. P. MOTORS
- SPECIAL DESIGNS

WRITE FOR COMPLETE ENGINEERING DATA

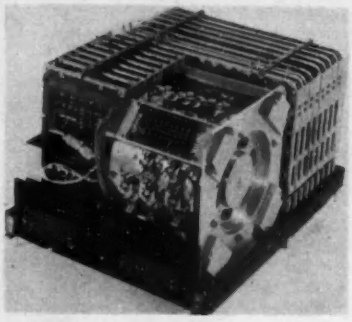
BORG Built by Borg

BORG EQUIPMENT DIVISION
Amphenol-Borg Electronics Corporation
JANESVILLE, WISCONSIN

CIRCLE 85 ON READER-SERVICE CARD

NEW PRODUCTS

DATA HANDLING & DISPLAY



32-LB COMPUTER

Photo shows the internal construction of the AN/ASN-24, a small, lightweight, multifunctional digital computer for airborne applications. Its immunity to environmental extremes suits it for guidance applications in a wide range of missiles as well as for solving navigational problems in high Mach number aircraft. Basically, the AN/ASN-24 is a two-address, serial, binary-data computer with digital impulses stored as 25-bit words on a 6,000-rpm memory drum. Each of the drum's 32 channels holds 64 words, providing a total storage of 2,048 words. Analog inputs are converted to digital form. After computation, outputs are displayed either on a main control console or on a range-bearing indicator. Errors are said to be less than 0.1 percent.—Librascope, Inc., Glendale, Calif.

Circle No. 201 on reply card

24-CHANNEL RECORDER

A new portable magnetic recording and playback system, the TI-551, has been designed primarily for use in seismic exploration. It provides 24 data channels, one timing channel, and two auxiliary channels. All recording and playback assemblies, power supply, and controls are contained in a single aluminum case with handle. Complete package weighs only 60 lb. Using a 12-vdc power source, the TI-551 records the output of any conventional seismic amplifier and requires a signal current of only 0.5 ma for full modulation. Response is essentially flat from 20 to 200 cps.—Techno Instrument Co., Los Angeles, Calif.

Circle No. 202 on reply card



NARROW RANGE

A new member of GE's CH recorder family, this narrow-range frequency recorder is designed for utility and industrial applications demanding close frequency checks. Standard model has a 58-to-62-cycle range, accuracy within 0.05 cycle, and completely self-contained construction. A full 6-in. strip chart covers the four-cycle range, and accommodates a 150-ft record roll. Unit is also available for center frequencies of 25 or 50 cps.—General Electric Co., Schenectady, N. Y.

Circle No. 203 on reply card

FIVE TIMES FASTER

The fully transistorized IBM 7090 computer offers speeds up to five times higher than those of its predecessor, the IBM 709. Suitable for both scientific and commercial applications, the 7090 system can add or subtract at a rate of 210,000 operations per sec, can store more than 32,000 ten-digit numbers in its magnetic-core memory, and can locate any one and make it ready for use in 2.4 microsec. Input and output equipment is compatible with all present-day IBM systems, as are programs developed for the 709 and 704 systems. First unit is scheduled for delivery in November.—International Business Machines Corp., White Plains, N. Y.

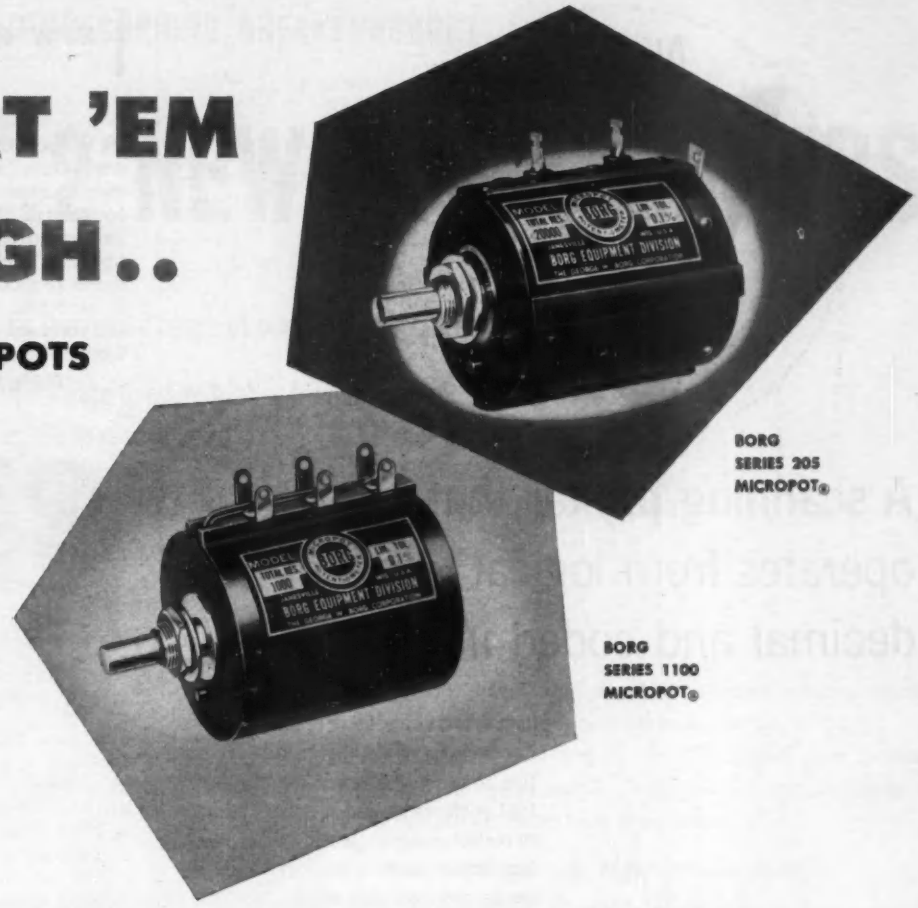
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NEW HEAT METER

A single circular-chart recorder in the Model 913 Btu Meter provides a permanent record of Btu loss or gain, temperature differential, and flow rate of a liquid. Its primary application is heat-transfer measurements in hot water generators, cooling towers, refrigerating systems, etc. Platinum resistance elements sense inlet and out-

TREAT 'EM ROUGH..

MICROPOTS CAN TAKE IT!



BORG SERIES 205 MICROPOT®

BORG SERIES 1100 MICROPOT®

We're rough on Borg Micropots, too — when it comes to testing for reliability. Take Series 205 and 1100 Micropots for example . . .

	Mechanical Rotation	Electrical Rotation	Linearity Accuracy	Torque Starting	Torque Running	Life Expectancy
Series 205	3600°+15°−0°	3600°+14.4°−0°	±0.1% to ±0.05%	−3.0" oz.	−1.5" oz.	1,000,000 revolutions plus
Series 1100	3600°+30°−0°	3600°+15°−0°	±0.5% to ±0.1%	−3.0" oz.	−1.5" oz.	500,000 revolutions plus

Testing of this type tells us how life and reliability are affected . . . the environmental limitations for each model . . . which series to recommend for your specific job!

You may be using high-priced pots unnecessarily in your present project. You may be able to reduce the number of components in your circuits. Remember . . . the fewer the components, the greater the reliability!

Let us send you the name of your nearest Borg "Tech-Rep" and a complete rundown on all Borg Micropots today.

Write for CATALOG BED-A90

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CIRCLE 86 ON READER-SERVICE CARD

New from...

Clary!

A scanning printer that operates from logical levels of both decimal and coded information!

Here at last is a fast, versatile scanning printer that draws negligible power from data sources. This unique feature allows the Clary Model 1961 printer to be used in systems that have no contact closures...lets it operate directly from logical levels of circuitry – from both decimal and coded data sources.

In addition, the Clary Scanning Printer...

prints 3 lines per second with a capacity of 12 digits per line • has an electrical selector that color prints in black and red • comes with a manual input keyboard as standard equipment • has fewer moving parts...insures reliability.

For more information on the Clary Model 1961 Scanning Printer, write today for Engineering Bulletin No. S-111.

Clary Corporation
Electronics Division
San Gabriel, California

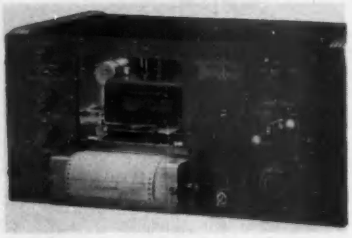


CIRCLE 87 ON READER-SERVICE CARD

NEW PRODUCTS

let temperatures and form two legs of a resistance bridge in which the differential temperature receiver in the recorder acts as a rebalancing unit. The differential temperature signal is multiplied by the signal from a flow transmitter to produce a signal proportional to heat rate. This is then integrated and recorded on the chart.–The Hays Corp., Michigan City, Ind.

Circle No. 205 on reply card

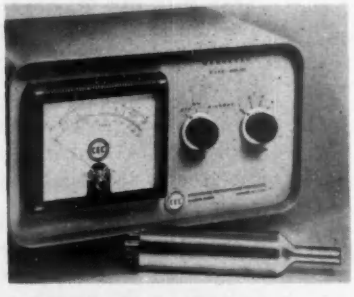


SERVO-OPERATED

The Type 1521-A Graphic Level Recorder is a pen-type, servo-operated, transistorized recorder that plots the rms level of ac voltages from 20 cps to 200 kc, can also be used as a linear dc recorder. Chart speeds range from 2.5 in. per hour to 75 in. per min. Writing speeds go as high as 400 db per sec. The unit automatically plots frequency characteristics.–General Radio Co., Cambridge, Mass.

Circle No. 206 on reply card

RESEARCH, TEST & DEVELOPMENT



COVERS TWO RANGES

The Magnevac, a new, wide-range vacuum gage, features a simple, rugged circuit that assures long life and minimum maintenance. Heart of the unit is a stable, magnetic-type ampli-

PHOTORECORDING BREAKTHROUGH!

NOW...2 NEW KODAK PAPERS

- Cover the entire range of commonly used frequencies and writing speeds.
- Extend that range to cover higher frequencies and writing speeds difficult or impossible to record up to now.
- Give you sharp, black traces throughout, even on wide amplitudes, sudden beam excursions or sharp rise times.

KODAK LINAGRAPH 44

RELATIVE TUNGSTEN SPEED: 20
THICKNESS: .0030 INCH

Orthosensitized on extra-strong paper support, specially designed for recording optimum trace density and contrast from low to moderately high writing speeds. Can be processed in the CEC Datarite Magazine.

KODAK LINAGRAPH 77

RELATIVE TUNGSTEN SPEED: 80
THICKNESS: .0030 INCH

The ultimate in high-speed, orthosensitized recording papers. Records extremely high writing speeds heretofore considered impractical, yet still retains good trace densities. Covers writing speeds up to 25,000 ips. Because of its wide exposure latitude it records medium-speed traces as well, with excellent clarity. On specially-made rugged, durable paper stock.

Now *two* new Kodak papers for all your photorecording needs. For writing speeds up to 25,000 ips.

Traces are easy to read by visual inspection or on data reduction equipment . . . easy to calibrate, and easy to duplicate on diazo-type equipment.

NEW . . . EXTRA-THIN, EXTRA-TOUGH BASE

Both new papers have a specially-treated super-strength base that really stands up under processing, handling, rolling, folding and storage. Extra thin (.0030") for more footage per given roll diameter. Rolls up to 475 ft. are splice-free. Surface readily accepts notations in pen or pencil.

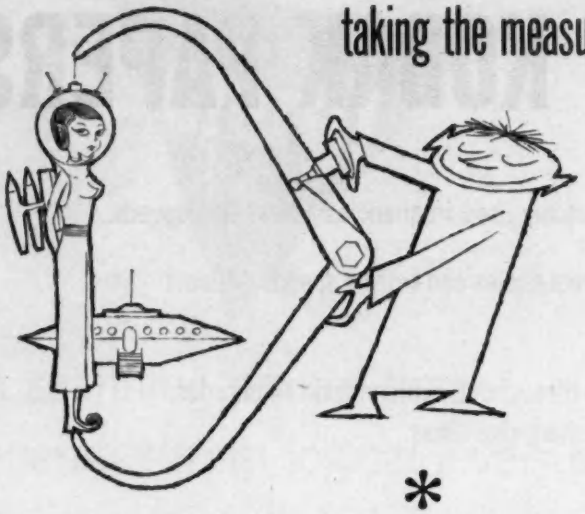
UNIVERSAL PROCESSING

You can process both papers in continuous, rewind, or stabilization type equipment. After stabilization, records can be handled immediately, without fear of brittleness, cracking or tearing.

Linagraph 44 and 77 Papers are available in all standard sizes. We'll welcome the chance to discuss your own particular application. Write for the complete technical details.

EASTMAN KODAK COMPANY
Photo Recording Methods Division
Rochester 4, N. Y.

Kodak
TRADE MARK



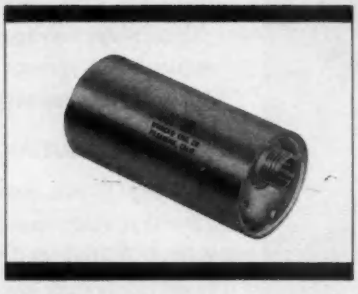
taking the measure...

*

...of heaven-sent objects ?

*

Here is an ideal accelerometer for airborne and ground-based telemetering applications



WIANCKO DC ACCELEROMETERS 0-5 VOLTS DC OUTPUT

Compare these specifications

• High vibration resistance	Output voltage .....0-5 v dc into 250,000 ohm load
• Constant output impedance	Ranges .....0-0.5 g to 0-100 g (± ranges available)
• Continuous resolution	Linearity .....<1.0% of acceleration span
• Light weight	Hysteresis .....<0.1% of acceleration span

Our Product Bulletin 110 contains further information. Send this coupon.

wiancko

WIANCKO ENGINEERING COMPANY

255 North Halstead Avenue • Pasadena, California

NAME _____ TITLE _____

ADDRESS _____ CITY & ZONE _____

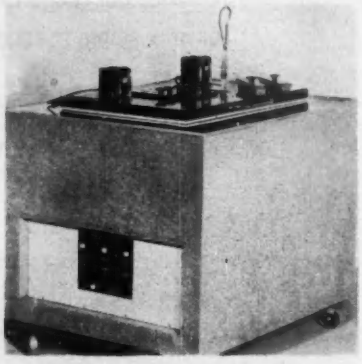
STATE _____ COMPANY _____

CIRCLE 89 ON READER-SERVICE CARD

NEW PRODUCTS

fier. Front-panel knob permits range selection (1 to 100 microns or 1 micron to 500 mm Hg); second knob scans four stations. Recorder taps provide for driving a 15- or 50-mv high-impedance recorder. – Consolidated Electrodynamics Corp., Rochester, N. Y.

Circle No. 207 on reply card



THERMISTOR-CONTROLLED

Called Produc-temp Baths, new variable temperature baths are now available for testing electronic components, thermostats, and other equipment requiring highly accurate test conditions. One unit, a combination bath, has a range of minus 55 to plus 100 deg C and 10 separate thermistor controls for complete programming of temperature changes. On this model, a 1-hp motor provides a 150-gpm circulation rate.–Labline, Inc., Chicago, Ill.

Circle No. 208 on reply card

WIDE-RANGE ACCURACY

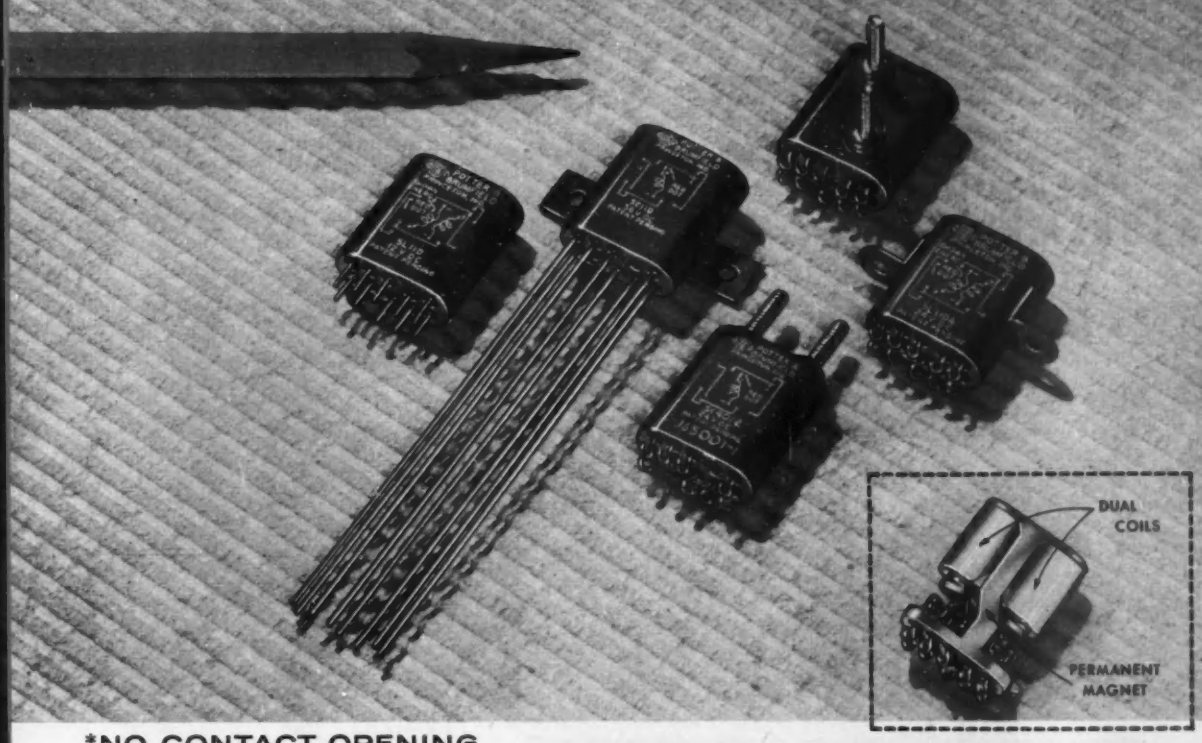
Two new wide-range Wheatstone bridges provide new upper limits of 100 and 1,000 megohms. On the 1,000-megohm unit, resistance values can be measured to within 0.05 percent. Accuracy on the 100-megohm unit is within 0.2 percent. Both models feature an exclusive "calibrated unbalance" that permits the user to set the decade selector to a desired resistance and read directly from the null-indicator scale the percentage by which an unknown resistor deviates from this value. A sensitive dc amplifier circuit assures excellent stability and reliability.–Millivac Instruments Div., Cohu Electronics, Inc., Schenectady, N. Y.

Circle No. 209 on reply card

P&B MICRO-MINIATURE RELAYS LEAD IN

performance

SHOCK: 100g* VIBRATION: 30g to 2000 cps*

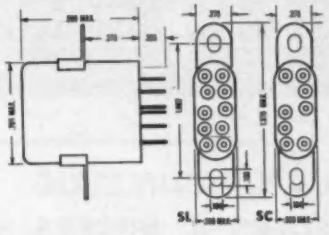


*NO CONTACT OPENING

New P&B crystal-case size relays, the SC and the SL (magnetic latching), show amazing shock and vibration capabilities. They absorb shocks of 100g and vibrations 30g to 2000 cps. without contact openings!

A highly efficient magnetic structure utilizing a permanent magnet makes possible at least twice the contact pressure found in DPDT relays of comparable size. One watt of power for three milliseconds operates either relay. Transfer time is unusually fast —0.5 milliseconds maximum.

For more information, contact your P&B sales engineer, or write Potter & Brumfield, Princeton, Indiana.



SL—dual coil latching relay. Operates on a 1 watt, 3 ms. pulse at nominal voltage. Permanent magnet latch locks the armature in either position.

SC—non-latching relay with series-connected dual coils. Operates on approximately 1 watt at nominal voltage. Coils must remain energized to hold the armature in the operate position.

SC and SL Series Engineering Data

GENERAL:
Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: —65° C. to + 125° C.
Weight: 15 grams without mounting bracket.
Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board.
(2) Hook end solder for 2 #24 AWG wires.
(3) 3" flexible leads.
Enclosure: Hermetically sealed.

CONTACTS:
Arrangement: 2 Form C.
Material: Optional
Load: 2 amps. @ 28 V. DC, resistive; 1 amp @ 115 V. 60 cycles AC, resistive.
Pressure: SC—16 grams min.; SL—20 grams min.

COIL:
Power: Approx. 1.0 watt at Nominal Voltage.
Resistance: SL—40 to 10,000 ohms; SC—35 to 20,000 ohms.
Duty: Continuous.

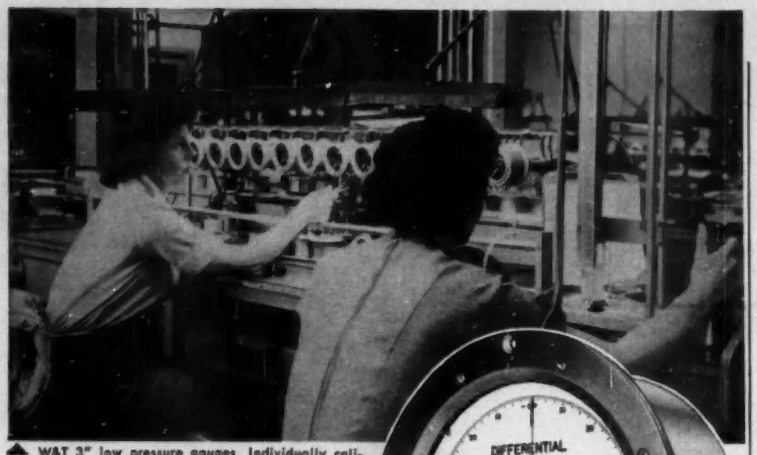
MOUNTINGS:
Bracket, stud and plug-in.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD INC.

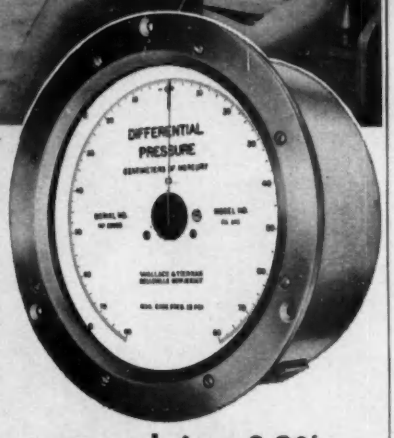
PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

CIRCLE 90 ON READER-SERVICE CARD



▲ W&T 3" low pressure gauges, individually calibrated, are checked against a precision standard.

A 6" gauge for easy readout is also available. ▶



PRESSURE MEASUREMENTS WITH PRECISION

W&T low pressure gauges bring 0.3% accuracy, rugged portability to your job

Calibration checked and double-checked . . . so you know the gauge is right when you record a reading. And W&T pressure gauges stay accurate in spite of rough handling. You can use them right on the job—still have laboratory accuracy.

These gauges are in stock now. For information write Dept. A-122.28

service: gauge pressure; differential pressure; vacuum determinations; or as compound pressure-vacuum gauges with zero center; **accuracy:** 1 part in 300; **sensitivity:** 1 part in 500; **minimum range:** 0 to 10 inches H_2O; **maximum range:** 0 to 400 inches H_2O; intermediate ranges of pressure or vacuum in any pressure equivalent are also available.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
IN CANADA: WALLACE & TIERNAN LTD., WARDEN AVE., TORONTO 13, ONT.

CIRCLE 91 ON READER-SERVICE CARD



MERCHEN GRAVIMETRIC FEEDERS & METERS

for dry free-flowing materials

- automatic batch control
- continuous blending
- materials accounting

Accuracy 1%
Rates 3 to 3000 lbs. per min.

Write for Bulletin No. M-32 .28

WALLACE & TIERNAN
INCORPORATED
25 MAIN ST., BELLEVILLE 9, N. J.

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

TESTING AID

A recently developed gyro console simplifies the entire procedure in response-testing rate gyros. The unit measures transfer functions and damping characteristics, and is engineered not only for accuracy but also for operator convenience. Its instruments include: low-frequency decade oscillator, low-frequency resolved components indicator, carrier converter, power supply, velocity pickup amplifier, rate vibration table, and table control unit. Gyro data is presented in the form of cartesian coordinates.—Solartron, Inc., North Hollywood, Calif.

Circle No. 210 on reply card



FOR HOT OR COLD SURFACES

A recent addition to this company's line of "Thermophil" electronic thermometers, the new surface thermometer offers accurate indication of temperatures as low as minus 328 deg F. The portable instrument measures only 7 by 5 by 2¼ in., contains a stable thermistor resistance element, bridge circuit, amplifier, and indicator.

Characteristics:
Range: minus 328 to 845 deg F
Time constant: 0.72 sec for liquids; 2.2 sec for surfaces
Full reading response: 5 and 15 sec
Readibility: within ½ deg F
Accuracy: within ¼ deg F
—Atkins Technical, Inc., Cleveland, O.

Circle No. 211 on reply card

PLUS . . .

(212) **A new primary pressure standard developed by Dynametrics Corp.,** Burlington, Mass., covers a pressure range of from zero absolute to 500 psig and is accurate to within 0.015 percent of full scale. . . . (213) **George A. Philbrick Researchers, Inc.,** Boston,

What a build!

... solid state components in New Fenwal Temperature Controller combine precision with extra reliability

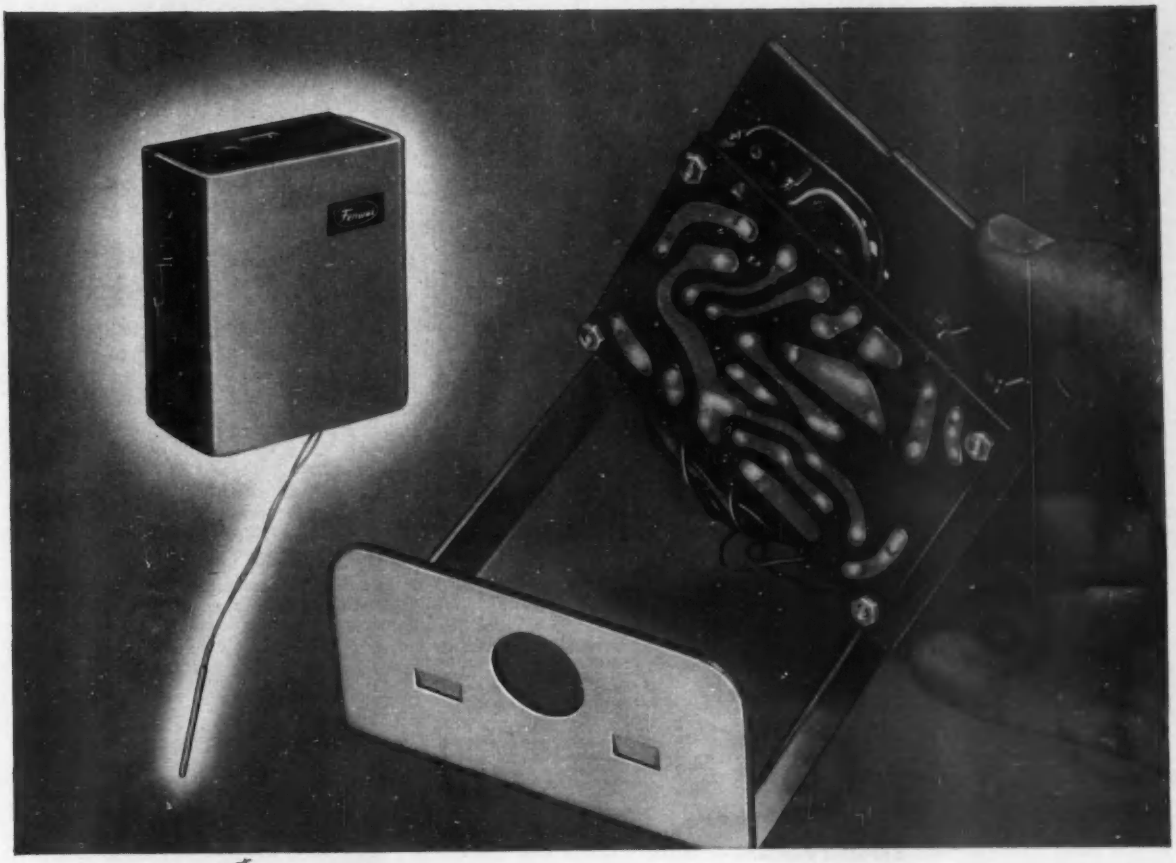
Here's a new, low-cost temperature controller that's really built "solid": thermistor sensing element, printed circuit, transistors. *No wonder the Fenwal 535 Temperature Controller provides high precision, trouble-free operation and long life!*

The Model 535's solid state components pay off in simplicity and dependability. The thermistor sensor mounts up to hundreds of feet from the controller using uncompensated electric wiring; has virtually limitless life; feeds into a rugged transistor amplifier. *No moving parts . . . nothing to wear out!*

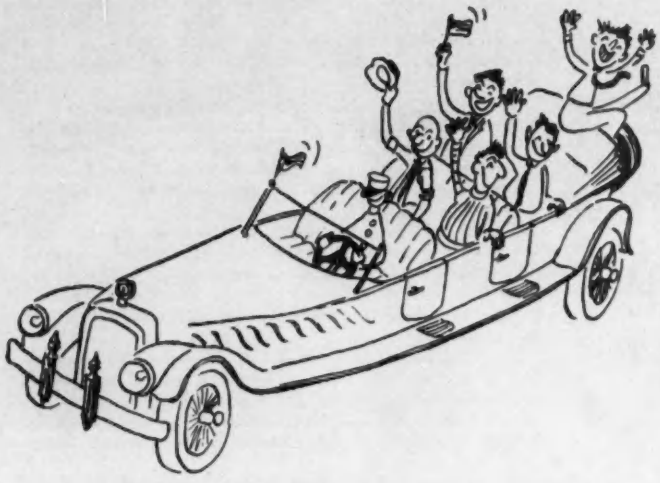
The Model 535 is the latest advance in the low-cost line of Fenwal Temperature Controllers specifically developed to fully exploit the advantages ... rapid response, compact size, reliability . . . of solid state components. *And Fenwal, alone, has integrated production of both controllers and thermistors.*

Use the Fenwal Model 535 Controller for fast response and close control of temperatures from −25°F to +600°F in plastics, packaging, or other critical applications. Get full details from a Fenwal Sales Engineer or write for catalog. Fenwal Incorporated, 294 Pleasant Street, Ashland, Mass.

Single point Model 535 Fenwal Temperature Controller has 2°F setting accuracy and sensitive operating differentials from 0.4°F to 1.2°F. Current capacity: 5 amps. 115 volts AC — 10 amp. model later in 1959.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY



UNSUNG HEROES

We wish we could afford a newer automobile with an emblazoned banner for *each* of these gentlemen*, to tell the whole relay-using world of their accomplishments. For these are the souls who design that seldom-heralded product—the plebeian Sigma relay. Unlike more renowned Sigma engineers, they can never go home at night and say "Today I built a relay that will make history"; instead, their efforts will only keep someone's juke box, remote-controlled toy, electric blanket or burglar alarm working.

Here are five of their achievements that are about as experienced as relays can be; the "4", "5" and "41" have proved themselves since early WW II days, the others almost as long. Being old standbys also means they're for sale and deliverable in quantity.

* Perhaps you recognize the man on the spare tire as Mackinaw L. Mundane of April 1958 fame.

AC		DC
Built-in rectifiers. Operation comparable to DC performance, except for coil overload capacity and speed.	 Series 4	Rugged, lightweight general-purpose SPDT design with adjustable pull-on and drop-out. Standard sensitivity 20 or 50 mw., rated 2 amperes resistive for 100,000 operations.
	 Series 5	Dual coils, SPDT, sensitivities from 1 mw. to 2 watts. High stability and shock resistance. Available adjustments include precision DC, close differential, meter protection, break-delay, etc.
Shaded pole version, for 60 cycle positive ON-OFF operation only. Standard sensitivity 0.3 volt-ampere. Type 11F — 1 1/16" x 1 1/16" x 1" high, wt. 1 oz. max.	 Series 11	Small, low cost ($1.50-2.45) SPDT relay. Ideal for remote control units for toys and TV sets, door openers, etc. Mechanical life 100,000,000 operations. Four mtg. styles, un-enclosed only.
Shaded pole SPDT design. Sensitivity 0.06 to 0.40 volt-ampere, 60 cps (specials for 16-400 cps.) Long life; quiet, inexpensive. Ratings up to 5 amperes resistive.	 Series 41	DC sensitivities 40 to 200 mw. Fast, bounce-free switching; useful for keying; speeds to 100 pps. Shock and constant acceleration up to 100 g will not cause damage.
DPDT version of Series 41, but with 0.30 and 0.50 volt-ampere standard sensitivities. Standard frequency 60 cps, specials 16-400 cps. Contacts rated 2 or 5 amperes. Economical of power.	 Series 42	DPDT version of Series 41, but with 100 and 200 mw. standard sensitivities. Can serve as output relay of many electronic controls; often used where UL approval is required. Contacts rated 2 or 5 amperes.

Bulletins on any of these Series on request.

SIGMA

SIGMA INSTRUMENTS, INC.
69 Pearl St., So. Braintree 85, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)

CIRCLE 94 ON READER-SERVICE CARD

NEW PRODUCTS

Mass., has introduced the Model K5-M **Multiplier-Divider**—a precision analog computing component with improved long-term stability. . . . (214) Fast response, high accuracy, and remote indication characterize a new portable **Electro-Hygrometer,** recently introduced by **Labline, Inc.,** Chicago, Ill.

Circle No. 212, 213 or 214 on reply card

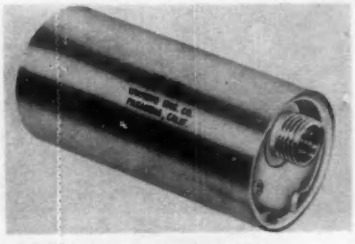
PRIMARY ELEMENTS & TRANSDUCERS



DESIGNED FOR MISSILES

This Model N4100 cageable, two-axis, free gyro weighs only 3½ lb, is designed specifically for missile applications. Maker claims it will stand vibrations of 10 to 1,000 cps at 10 g and 1,000 to 2,000 cps at 20 g with 2-min sweep cycles, without vibration isolators. Angular displacements are indicated by a synchro pickoff on the outer gimbal.—Electronics Div., Iron Fireman Mfg. Co., Portland, Ore.

Circle No. 215 on reply card

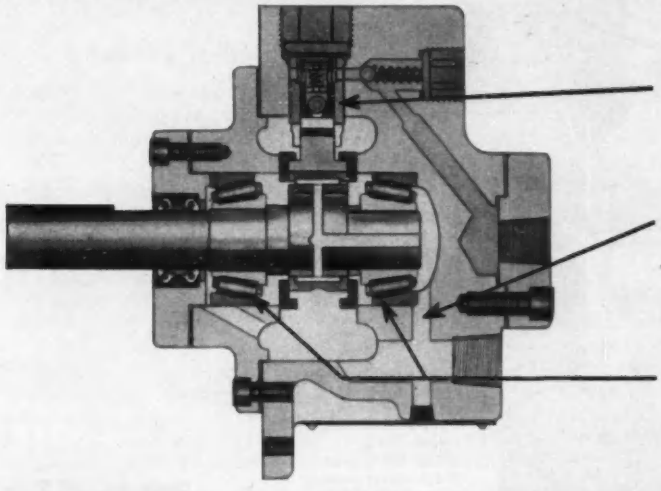


NEEDS NO AMPLIFIER

Combining a solid-state carrier oscillator and ring demodulator with a variable-reluctance pickup results in

AT PRESSURES TO 5,000 PSI . . .

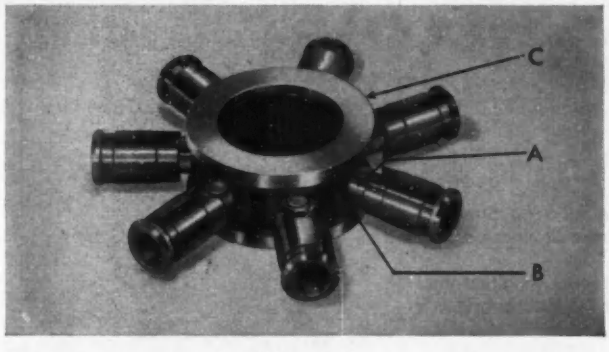
Only the AE Hydramite offers all these advantages



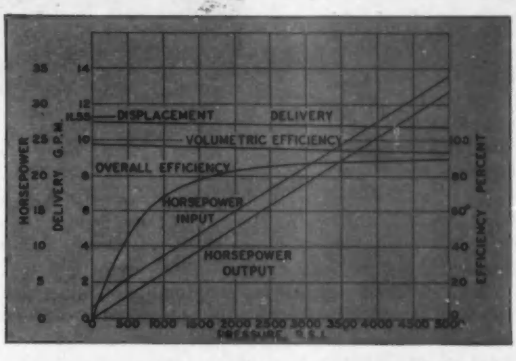
Liners and plungers are honed and individually mated for optimum fit.

Low friction losses. Pump operates with case flooded. Oil is ported to take advantage of natural pumping action of tapered bearings.

Heavy duty, high capacity tapered roller bearings absorb more punishment . . . handle maximum unbalanced loads . . . last longer.

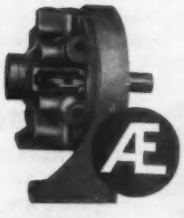


Positive pumping action. The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled inward by the return rings.



High efficiency. With a Hydramite you get an overall efficiency of 85%. Its flat overall high efficiency curve has little variation between 1,500 and 5,000 psi. What's more with a Hydramite you get positive suction. There is no requirement for supercharging equipment which deducts from system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Philadelphia 37, Pennsylvania. Phone: Cumberland 9-3800.



AMERICAN ENGINEERING COMPANY

Hale-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra Grate, Perfect Spread and Taylor Stokers.

CIRCLE 95 ON READER-SERVICE CARD

NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



Detector for Perkin-Elmer Model 154-C Vapor Fractometer (above) gets highly stable voltage from tiny but precise Sorensen dc supply (below). Dimensions are only 3-9/16 x 3-1/16 x 5 in.

high-precision vapor fractometer gets Sorensen transistorized supply

provides *"better accuracy"* says Perkin-Elmer

Perkin-Elmer Corporation, Norwalk, Connecticut, selected a modified Sorensen miniature transistorized supply to build into the hot-wire detector unit for their new precision Model 154-C Vapor Fractometer.

They report they're pleased with the speed with which Sorensen modified their standard Model QM miniature voltage-regulated dc supply to fit their specialized requirements and they praised Sorensen's quick deliveries. But here's the statement we, at Sorensen, liked best:

The QM ". . . appears to afford even better regulation than Sorensen's specifications show (better than ±0.05% variation in output voltage for a 10% change in line voltage)." Need we say more?

Sorensen makes the widest line of transistorized power supply equipment on the market today—plus a complete line of electronic and magnetic-amplifier regulators for ac and dc, inverters, converters, and frequency changers, plus a complete line of extremely high-voltage equipment. Write for catalogs. And if you have a special problem or tough specifications to meet, ask the advice of your nearest Sorensen representative—he'll have the answer. 8.48

Sorensen

SORENSEN & COMPANY, INC.

Richards Avenue, South Norwalk, Connecticut

WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. IN WESTERN CANADA, ARVA. IN EASTERN CANADA, Bayly Engineering, Ltd. IN MEXICO, Electro Labs, S. A., Mexico City.

CIRCLE 96 ON READER-SERVICE CARD

NEW PRODUCTS

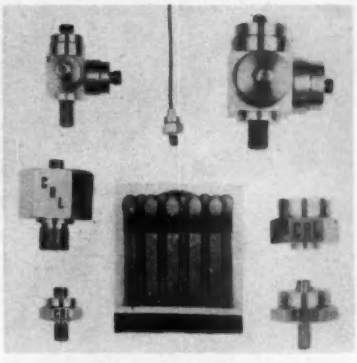
this compact dc accelerometer for aircraft and missile applications. Features include continuous resolution, 0-to-5-vdc output at constant impedance, low hysteresis, and excellent linearity.—Wiancko Engineering Co., Pasadena, Calif.

Circle No. **216** on reply card

PULSE COUNTERS

A series of transistorized, zero-speed Rotopulsers has been developed for industrial applications such as continuous measurements of length, rpm, position, belt speed, etc. Units generate up to 1,200 counts per revolution and can measure length increments as small as 1/100th in.; operating speeds may exceed 10,000 rpm. Units can be located more than 100 ft from the control equipment without loss of reliability or accuracy. Temperature range can be extended by mounting the transistorized circuit in a separate power-transformer case. Life rating on all components is five years.—Dynapar Corp., Skokie, Ill.

Circle No. **217** on reply card



USE NEW CRYSTAL

Shown are seven of 16 new accelerometers built to withstand ambient temperatures between minus 65 and plus 540 deg F without cooling or correction. Applications include high-performance testing of shock and vibration under extreme environmental conditions. Models range from heavy-duty to subminiature, with sensitivities from 30 mv per g to 1 mv per g. They use a newly developed piezoelectric crystal in a true compression-type seismic system to provide accuracies within 5 percent.—Columbia Research Laboratories, Woodlyn, Pa.

Circle No. **218** on reply card

CIRCLE 97 ON READER-SERVICE CARD →



GD60 AND 80 SERIES



GD100 SERIES



LR20B SERIES

Control gases safely, accurately

TO 15,000 PSI AND 50,000 SCFM WITH VICTOR REGULATORS

You get precise regulation of high pressure gases with large flow rates, because Victor employs gas pressure to control the regulating diaphragm. The result is accurate delivery from 5 to 15,000 psi with inlet pressures to 15,000 psi . . . plus ability to obtain flows in excess of 50,000 scfm at maximum inlet and outlet pressures. Chart below shows operating range of standard models.

MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

Operating temperature range: −67°F. to +250°F.

. . . Yours for the asking
Take advantage of Victor's long experience with high pressure gas regulation to help solve your special problems involving flow rates, delivery pressures, corrosive fluids and temperature compensation. Write, wire or phone us today. No obligation.

All models listed are field proved. Most are designed for panel mounting or remote control. They regulate all non-corrosive gases, including oxygen. Stainless steel models available for corrosive gases and pressures above 10,000 psi. For complete specifications, write for Victor High Pressure Regulator sheets.

VICTOR® for regulators

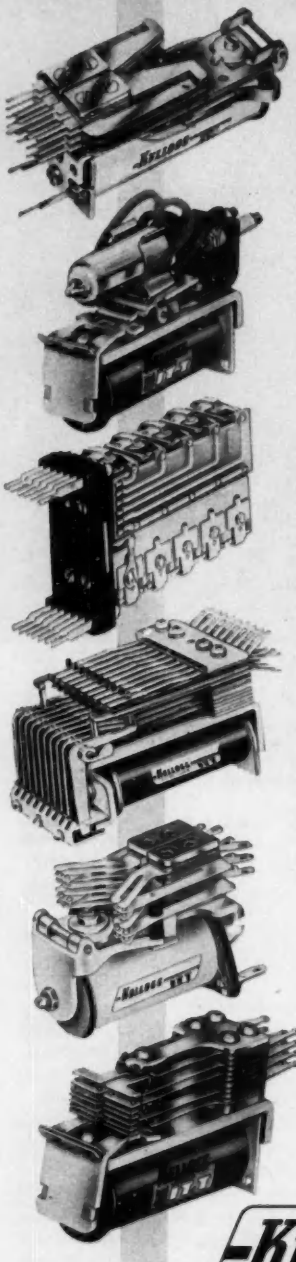
VICTOR EQUIPMENT COMPANY MISSILE DIVISION 57

Mfrs. of High Pressure and Large Volume Gas Regulators; welding & cutting equipment; hardfacing rods; blasting nozzles; cobalt & tungsten castings; straight-line and shape cutting machines.

844 Folsom St., San Francisco 7 • 3821 Santa Fe Avenue, Los Angeles 58 • 1145 E. 76th St., Chicago 19

J. C. Menzies & Co., Wholly-Owned Subsidiary

Industrial Relays by KELLOGG



Type "AK" Relay

Highly sensitive, adaptable for marginal operating; provides fast closing and opening of maximum number of circuits . . . long coil construction permits use of high resistance coils . . . may be engineered to operate on as little as .002 amps; slow operate or slow release models available.

Mercury-switch relay

For hazardous atmospheres: contacting elements hermetically sealed . . . will handle maximum of 25 amps., at 80 volts . . . must be mounted horizontally.

Duo-Quintet Relay

Designed for application as a memory device . . . can also be used in binary or binary decimal storage.

Magnetic Impulse Counter

Used to solve switching or control problems where the intelligence is supplied in the form of a series of electrical impulses . . . wide application in industrial control, computer design, telephone, microwave selective signalling and telemetering.

Type "L" Relay

A small version of telephone type relay . . . retains flexibility, sturdy construction and reliability of standard, telephone type relays, yet compact, lightweight and extremely versatile.

The "4000" Relay

Built to fulfill exacting requirements demanded by the modern industrial control designer . . . a high quality, general purpose, telephone type relay, with long life and extreme reliability.

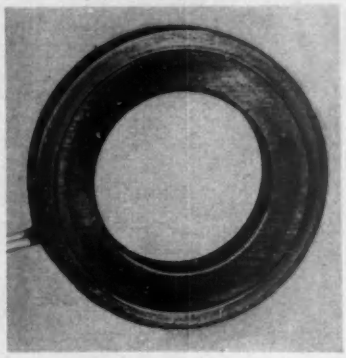
Kellogg will gladly engineer relays to meet any application — call Kellogg — or write — for full information on the complete Kellogg line of relays, components.

KELLOGG
CHICAGO, ILLINOIS
ITT

Kellogg Switchboard and Supply Company,
6650 South Cicero Avenue, Chicago 38, Ill.
Communications Division of
International Telephone and Telegraph Corporation
Manufacturers of: Relays
Hermetically Sealed Relays • Switches
Miscellaneous Telephone Type Components.

CIRCLE 98 ON READER-SERVICE CARD

NEW PRODUCTS



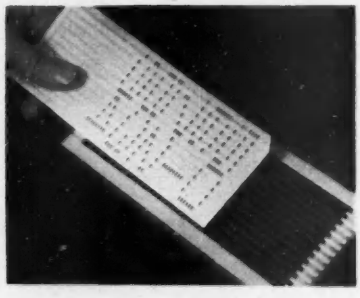
EASY TO INSTALL

This Model LTD-107 Washer-type force gage is essentially a load cell in the shape of a washer. It is wound with strain-sensitive resistance wire and is slightly thicker than a standard flat washer. Used in place of a washer, the gage has sufficient compressive strength to withstand all normal bolt loads.

Characteristics:

Resistance: 120 ohms plus or minus 0.5 percent
Linearity: within 1 percent
Hysteresis: within 1 percent
Repeatability: within 1 percent
Sensitivity: on the order of one μ ohm per ohm full load
—Waldale Research Co., Inc., Pasadena, Calif.

Circle No. 219 on reply card



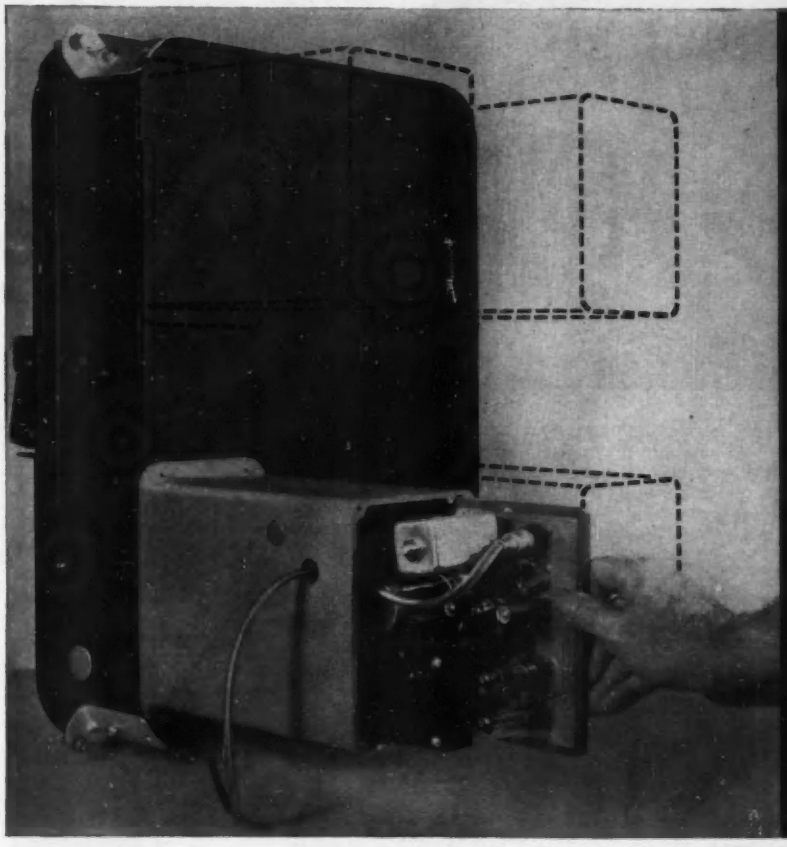
NEW SPACE SAVER

The Rex-Array photorectifier plate, developed at MIT's Lincoln Labs, is a new computer system component that behaves essentially like an array of diodes. A 4-in.-by-8-in. plate, currently being manufactured for a punched-card reader, has packing densities of 100 cells per sq in.; much higher densities are also possible. The plates require less space and less soldering than similar networks using photodiodes, and operate only when illu-

for economical remote recording of temperature...

THE NEW HAGAN TC (THERMOCOUPLE) POWRLOG!

LOW first cost
LOW maintenance cost
LOW parts inventory cost



UNIQUE CONSTRUCTION — same amplifier used for all temperature applications by simply changing plug-in input box.

UP TO FOUR different variables may be recorded on the same chart.

ACCURATE — PowrLog's resolution is 0.1% of full scale, overall instrument accuracy—0.5%.

FAST—with pen driveshaft torque of 45 in./lb., PowrLog achieves full scale pen deflection in 2 seconds.

STABILITY ASSURED—simple adjustment balances gain to resolution, no hunting or dead band problems.

The Hagan model TC (thermocouple) PowrLog receiver provides low cost remote measurement and/or control of temperatures with a high degree of accuracy. The system consists of an amplifier, drive motor and gear train as the basic unit. Associated with this basic unit are a series of plug-in input boxes, one for each type of measurement. Every component part has been selected for reliability, accuracy and long wear characteristics. The net result is the reduction of maintenance costs and problems to a new low.

Since the same high-gain AC amplifier is used in all applications, parts stocking problems are eliminated, with consequent savings in inventory costs.

Write for descriptive bulletin, or ask a Hagan engineer to explain the many specific advantages of the new PowrLog for temperature measurement and other applications.

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.

In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

CIRCLE 99 ON READER-SERVICE CARD

d&r LTD.

MODEL D-1309 INDUCTION GENERATOR

FOR MISSILE POWER



▶ LOW ROTOR INERTIA
LESS THAN 0.022 OZ. IN².

▶ LOW STARTING TORQUE
LESS THAN 1.5 OZ. IN.

▶ HIGH POWER TO WEIGHT RATIO
UP TO ONE HORSEPOWER PER POUND

▶ MAGNET PROTECTION
NO DEMAGNETIZATION DUE TO CIRCUIT OVERLOAD

▶ MASS PRODUCIBLE
RANDOM INTERCHANGEABILITY OF PARTS

▶ IMPROVED RELIABILITY
LARGE AIRGAP, CONSERVATIVE BEARING LOADS

The Model D-1309 is compact (1.5" O.D. x 1.67"), light weight (8.5 OZ.) and exhibits desirable performance characteristics. Its ratings at a shaft speed of 60,000 R.P.M. are:
Output frequency: 6,000 cps.
Power output: 100 Watts, single phase.
Other rotating power and control devices are available. WRITE FOR COMPLETE DATA.

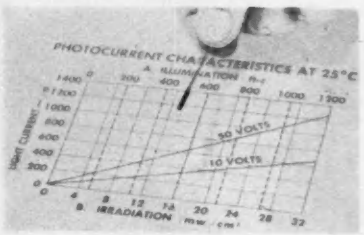
d&r LTD.
402 EAST GUTIERREZ STREET
P.O. BOX 1500, SANTA BARBARA, CALIFORNIA
TELEPHONE: WOodland 3116

CIRCLE 100 ON READER-SERVICE CARD

NEW PRODUCTS

minated. The last characteristic enables activation of required networks by simple masking techniques. Photo above shows a typical 4-by-8 plate under a standard punched card.—Rex Corp., West Acton, Mass.

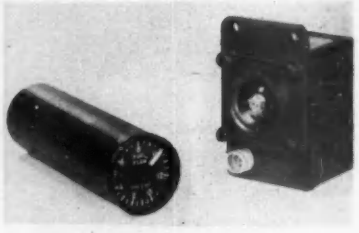
Circle No. 220 on reply card



MOST SENSITIVE

Barely visible in the photo above is TI's new subminiature light-sensing photo-duo-diode, a diffused n-p-n silicon type with a sensitivity four times as great as that of any other commercially available photosensitive unit. Its single-ended glass case measures only 0.5 in. long by 0.085 in. in diameter. Ideal for use in punched-tape and card-reading systems, the 1N2175 will pass up 1,200 μa when exposed to 1,200 foot-candles of light. In darkness, it passes less than 0.5 μa. Dissipation is rated at 250 mw at 25 deg C. Device operates on any bias up to 50 volts.—Texas Instruments, Inc., Dallas, Tex.

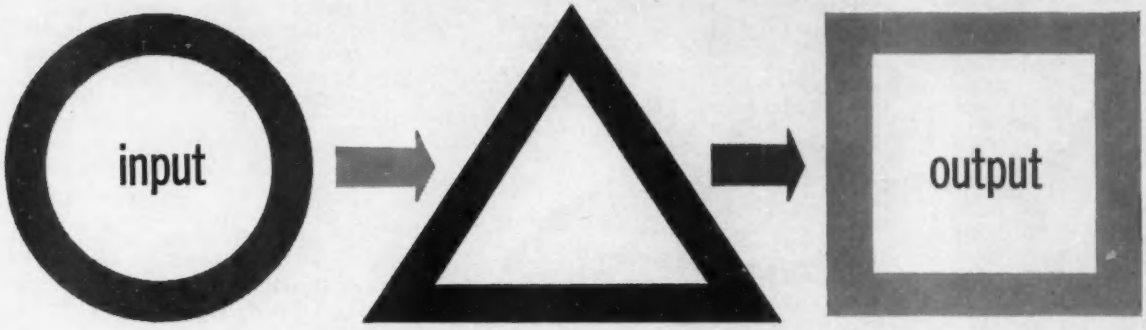
Circle No. 221 on reply card



MINIATURE SYSTEM

Shown is a new miniaturized mass flowmeter system for measuring fuel flow on reciprocating aircraft engines and small turbo-prop and jet engines. The highly-reliable system consists of two basic components: a type TJ-64 flowmeter transmitter and a type DJ-99 remote indicator. It provides continuous indication of the mass rate of fuel flow up to 1,200 lb per hour,

measure control... without contact...



Now—measure pressure, temperature, vibration . . . any physical quantity you can convert to a change in capacitance . . . without fuss, muss, or bother. Decker's Delta Unit takes the output from the simplest △ capacitance sensors you can devise, converts it to an analagous phase sensitive differential DC voltage for indication and recording.

The new 902-1 Delta Unit is based on Decker's patented T-42 Ionization Transducer. It provides all the advantages of the T-42 ready to use in a simple, compact package as versatile and flexible as your own imagination.

Accepting initial capacitances from 1 to 50 μμF, the 902-1 provides maximum signals of ±30 VDC. Sensitivity in the 5-20 μμF initial capacitance range is approximately 0.2V/% △ C. Unit is provided with a single measuring probe and cable assembly; however, two measuring probes may be operated simultaneously. Complete information is provided in Instrument Data Sheet 902-1, available on request.



THE DECKER CORPORATION *Bala Cynwyd, Pennsylvania.*

CIRCLE 101 ON READER-SERVICE CARD

Introducing the Donner 3400



10 Chopper Stabilized printed circuit amplifiers

Built-in 0.1% null voltmeter

Repetitive or continuous operation

Choice of 0.1% or 1.0% computing components

A NEW Desktop Computer WITH CHOPPER STABILIZED AMPLIFIERS

Donner's new 3400 analog computer combines high accuracy, flexibility, and economy. From its inception, design philosophy dictated the creation of a computer whose performance compared favorably with larger and more expensive equipment.

A complete Model 3400 consists of 10 chopper stabilized amplifiers, built-in null voltmeter and cyclic reset generator, 5 initial condition power supplies and supporting control and metering circuitry. Price of the basic Model 3400 is $2,190. The Model 3430 Removable Problem Board sells for $95. The purchaser can buy either 0.1% or 1.0% passive plug-in computing components according to the requirements of his problems. Two or more 3400's can be slaved together and operated from any one computer. Standard companion non-linear equipment such as function generators, and multipliers is available for operation with the 3400.



Donner engineering representatives are located in principal areas throughout the western world. Your nearest representative will be happy to arrange a demonstration. For the name of your nearest representative and complete technical information on the new Donner 3400, please address Dept. 084.

Model 3101 plug-in amplifier: *dc gain in excess of 50 million; maximum offset of a unity inverter, less than 200 μv/day; drift of unity integrator, less than 100 μv/sec; phase shift of unity inverter, less than 0.5 degrees at 1 kc. These amplifiers are also available for separate sale.*

DONNER SCIENTIFIC COMPANY

CONCORD, CALIFORNIA

Electronic engineers, exciting opportunity exists at Donner. Write today for full details.

CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

weighs less than 4 lb, and operates on 115-volt, 400-cycle power. — General Electric Co., Schenectady, N. Y.

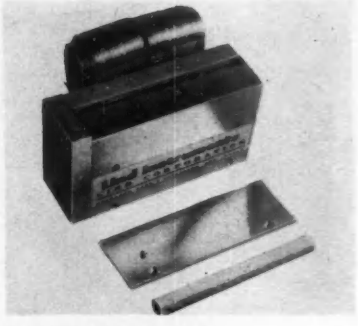
Circle No. **222** on reply card

PLUS . . .

(223) **Pioneer Magnetics, Inc.**, Los Angeles, Calif., has added two new models to their line of precision **frequency-to-voltage transducers**. . . . (224) Design of a new two-pole, three-phase **tachometer generator** by **General Electric Co.**, Schenectady, N. Y., features a 26-to-12-oz weight reduction. . . . (225) **National Instrument Laboratories, Inc.**, Washington, D. C., has developed a **mass flowmeter** for gases, in which bellows compensate for temperature and pressure changes by varying the size of the orifice. . . . (226) A new 13-digit photoelectric **shaft-position encoder** is announced by **Wayne-George Corp.**, Boston, Mass.

Circle No. **223, 224, 225** or **226** on reply card

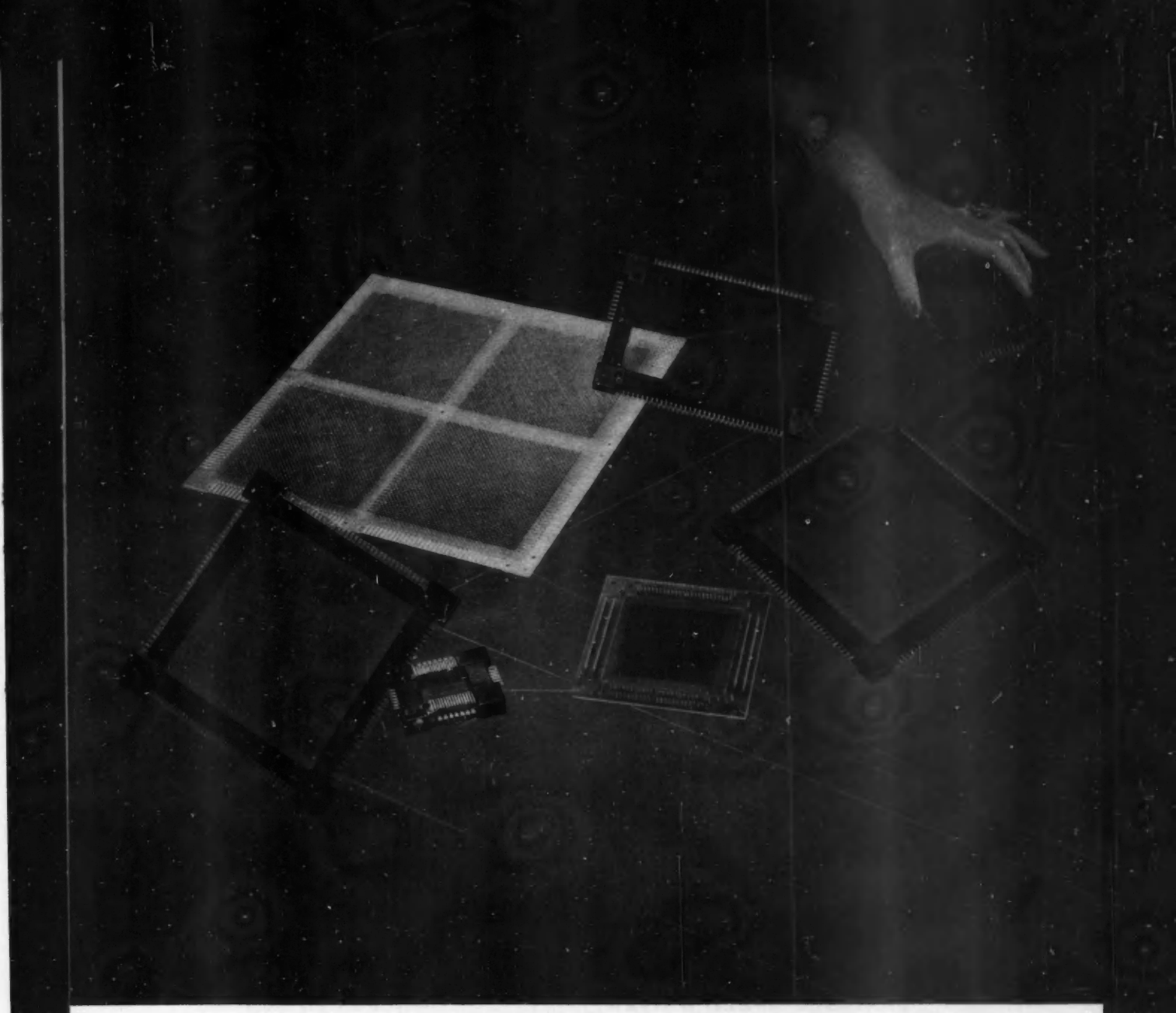
CONTROLLERS, SWITCHES & RELAYS



EXTRA-LONG LIFE

Well-suited for telemetering strain-gage and thermocouple signals, this compact commutator is said to have 300 times the life of circular sampling switches. A two-pole switch, with 60 contacts per pole, it occupies less than 12 cu in. and weighs only 12 oz. The unit will operate under vibrations of 36 to 2,500 cps at 25 g and can withstand 150 g for 11 msec. Its life at 10 rps is in excess of 1,000 hours.—Lind Corp., Princeton, N. J.

Circle No. **227** on reply card



Find the missing memory plane

The seven memory planes above each solved some special memory problem. There is one plane missing. It's the one which will solve your problem. You'll find the plane at General Ceramics which offers a complete memory plane service, backed by broad experience in the design, engineering and mass production of planes, frames and cores.

DESIGN SERVICE– An experienced design engineering staff stands ready to analyze your memory plane requirement, recommend and develop the plane that will meet your application in the most efficient and least expensive manner.

MANUFACTURE– Skilled factory personnel, utilizing the most advanced equipment and techniques and continually working in all phases of memory plane development and manufacture will produce the plane. General Ceramics has developed and wired memory planes containing from 64 to 16,384 cores each. (Core sizes range from 50 mil OD to 80 mil OD.)

QUALITY CONTROL– An expanded testing department with fully automatic and semi-automatic testing equipment, developed at General Ceramics, assures you complete quality control and the highest standards of manufacture.

STANDARD LINE– Perhaps some of General Ceramics' line of standard memory frames will meet your requirements. Write for literature on General Ceramics standard planes. Address inquiries to General Ceramics Corporation, Keasbey, N. J.–Dept. CE.

GENERAL CERAMICS

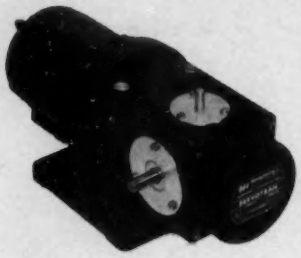
ORIGINATOR OF THE SQUARE LOOP FERRITE

Manufacturers of FERRAMIC CORES, MAGNETIC MEMORY CORES, MEMORY PLANES, MICROWAVE FERRITES, SOLDERSEAL TERMINALS, HIGH TEMPERATURE SEALS, STEATITE, ALUMINA and CHEMICAL STONEWARE

CIRCLE 103 ON READER-SERVICE CARD

Pick the Servotran variable speed drive for *your* power requirements

PAT. NO. 2816421
OTHER PATS PEND.



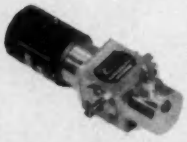
1/40 to 1/10 hp

This 3-inch square Servotran provides real power capacity for applications requiring variable speed drives or remote controls up to 1/10 hp. Output torque is constant and efficiency is between 85 and 95%. Repeatability and accuracy of speed setting is within ½%.



1/100 to 1/40 hp

This 2-inch square Servotran is no larger than an ordinary gear box, yet it provides output shaft speeds infinitely variable over more than a 100 to 1 range. It is excellent for computers, recorder drives, small coil winding machines and similar applications.



1/1000 to 1/100 hp

This 1-inch square Servotran weighs only ¼ lb. It is ideal for instrument drive applications, signal generators, small remote control mechanisms, etc.

A FULL RANGE OF PRECISION VARIABLE SPEED DRIVES

There is a model of the Servotran available for all applications from signal generators and computers requiring almost no power to heavy power controls needing up to 1/10 hp. You can match the Servotran to your load requirements. . .wherever low torque shifting, high efficiency, wide speed range and low noise levels are important. Positive speed adjustment can be obtained by using an accurately calibrated 10-turn dial. Speed may also be adjusted by means of a flexible push-pull cable for manual remote control and by solenoid control for electrical remote control.

For more information, write today to Humphrey Products Division, Dept. C-49, 3794 Rosecrans Street, San Diego 10, California.

Humphrey Inc.
HUMPHREY PRODUCTS DIVISION
3794 ROSECRANS STREET, SAN DIEGO 10, CALIFORNIA

CIRCLE 104 ON READER-SERVICE CARD

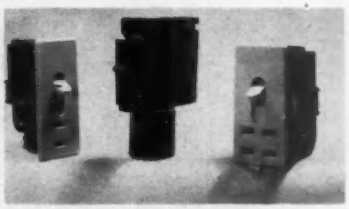
NEW PRODUCTS



SOLID-STATE RELAY

Designed for today's critical electronic switching requirements, this tiny relay has no moving parts, yet provides snap-action characteristics with a pickup of approximately 5 μsec and drop-out time of 30 μsec. Contact bounce, arcing, and contamination problems are completely eliminated. Its 28-vdc coil circuit is isolated from the switching circuit; the unit responds to 18-volt pickup and 11-volt drop-out. The spst type switches ac or dc from 10 ma to 10 amp; the spdt type, 10 ma to 0.5 amp. —Pendar Inc., Van Nuys, Calif.

Circle No. 228 on reply card



SWITCH-RATED BREAKERS

Designated Type SA, this new line of low-amperage circuit breakers meets the current demand for small, rugged, switch-rated units that can be used with motors, appliances, electronic apparatus, and industrial equipment. Center unit is available in 5-, 10-, 15-, and 20-amp ratings; two other 15-amp units are available with one or two convenience outlets. All ratings are for 120-volt operation. Prices are comparable to similarly-rated fusible units. —Federal Pacific Electric Co., Newark, N. J.

Circle No. 229 on reply card

SELF-STEPPING

Basically a Type F crossbar switch, the Model SC-4 Scanner uses a simplified



Here is the low-cost, desk-side electronic digital computer you need for general design and system optimization

Speeds optimum design of new products and equipment!

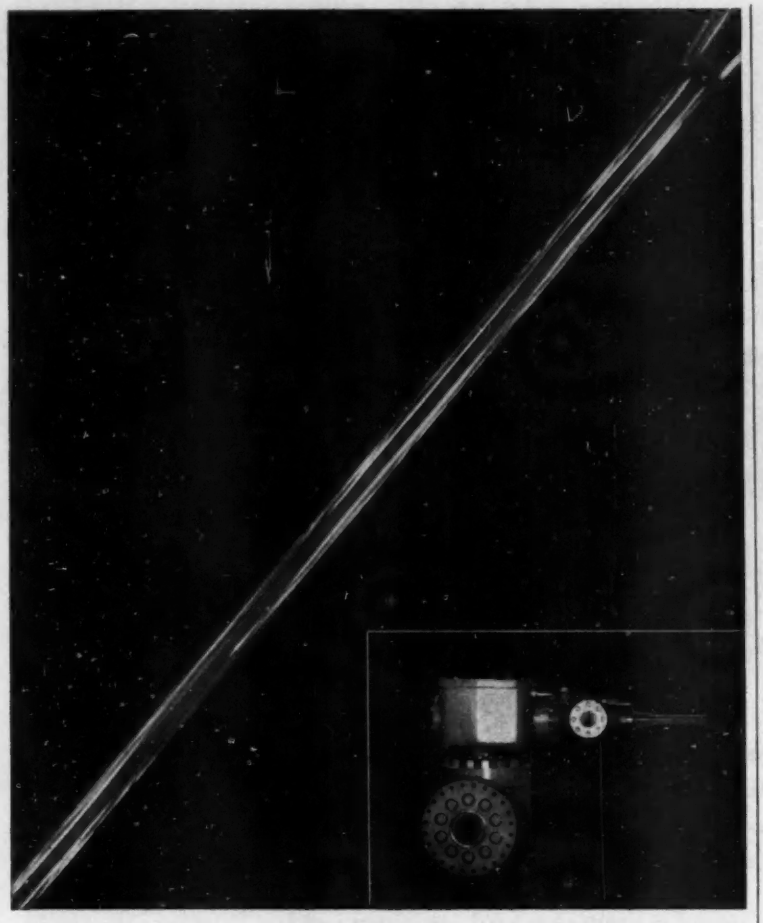
Operating from any convenient wall outlet, the compact, powerful LGP-30 will today furnish you with high-speed electronic computation wherever you need it . . . will eliminate tedious hand calculations . . . help you free up more creative time.

Combining large memory (4096 words) and stored-program operation, the LGP-30 gives you twice the capacity of any computer in its class, yet is by far the easiest to program in basic machine language. Simplified controls can be operated with only minimum computer experience. Answers are printed out directly—require no deciphering. Best of all, even with these many unique advantages, the LGP-30 is the lowest-priced complete computer you can buy. What's more, auxiliary high-speed input—output equipment is available for system expansion.

No expensive installation or air-conditioning required. Customer training is free. An extensive library of programs and sub-routines is available—as well as membership in an active users organization. Sales and service facilities are maintained coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y. In Canada: The McBee Company, Ltd., 179 Bartley Drive, Toronto 16.

ROYAL McBEE · *data processing division*



Using stop motion, photographer Bernard Hoffman "freezes" a tiny jet of water. Discharged at high pressure, the stream is a solid, unwavering mass.

SPLIT-SECOND CONTROL OF TIME AND PRESSURE

Take the valve pictured above. This 10-inch, high-speed Rotovalve was designed for rapid flow control at a Langley Field test installation. It will fully open, or close, in one-tenth of a second against water under free-discharge conditions at 3,260 pounds per square inch pressure.

How much pressure is involved in your application? How fast must you operate? What's the volume? Dozens of questions must be considered to relate all the factors that influence a fluid control problem. They require specialized engineering . . . the kind you get from Allis-Chalmers.

A-C Rotovalves may be your answer. Their full-line opening offers no obstruction to flow. They may be designed to give you extremely close control of closing time. Positive closure gives completely tight shut-off against either pressure or vacuum.

If you have a fluid control problem, A-C offers you a broad background of specialized valve engineering and application skills. To find out more about how we might assist you, contact your nearest A-C valve representative, or write Allis-Chalmers, Hydraulic Division, York, Penna.

Hydraulic Division RESEARCH DESIGN HYDRODYNAMICS ENGINEERING FABRICATION

Rotovalves • Ball Valves • Butterfly Valves • Free-Discharge Valves

Hydraulic Turbines & Accessories • Pumps • Liquid Heaters

ALLIS-CHALMERS

CIRCLE 106 ON READER-SERVICE CARD

drive circuit to connect sequentially a six-wire circuit with each of 100 sets of six-wire terminals, at speeds up to 60 sets per sec. Applications include thermocouple and strain-gage scanning, automatic circuit testing, and marginal checking. The unit requires only two mercury-wetted, contact-type relays in addition to the crossbar switch. The switch itself has a life of 20 million operations per cross-point without adjustments.—James Cunningham, Son & Co., Inc., Rochester, N. Y.

Circle No. **230** on reply card



CHECKS AIR SPEED

Available with one or two spdt switch elements, this device responds to differential air pressure. In a typical application, monitoring air speed, the ports are connected to sense pitot and static pressures. The reference or static port can be screened for ambient pressure sensing. Switches can be set to activate circuits at any preset pressure difference between 2½ and 135 in. of water.—Consolidated Controls Corp., Bethel, Conn.

Circle No. **231** on reply card

PLUS . . .

(232) **Guardian Electric Mfg. Co.**, Chicago, Ill., is offering a 10-amp, 4pdt **aircraft and missile relay** that meets or exceeds MIL-R-6106-B. . . . (233) The **Series 663 Dynamaster instruments**, now available from **The Bristol Co.**, Waterbury, Conn., are easily adapted to ratio, cascade, and computer-type control systems. . . . (234) A completely transistorized **electronic switch**, Model 129-A, has been added to its standard line of digital system building blocks by **Navigation Computer Corp.**, Philadelphia, Pa.

Circle No. **232, 233** or **234** on reply card



Also latest data control concepts for missile and undersea applications

The AiResearch Centralized Air Data Computing System will sense, measure and automatically correct for air parameters affecting flight of the North American-Air Force F-108 Interceptor and will supply simplified air data to the pilot. Eliminating duplication of components, the system will cut down space and weight requirements over decentralized systems by many times.

The centralized combination of transducers, computers and indicators represents an integrated system concept combining electrical, electronic, pneumatic, hydraulic, electro-mechanical and mechanical servo capabilities. Technical experience in each of these fields enables AiResearch to achieve optimized systems covering a wide range of functions while meeting the most rigid specifications. Systems management is an integral part of each Central Air Data program enabling AiResearch to assume the overall responsibility for systems or subsystems.

The first fully optimized central air data system is already operational aboard the Navy's supersonic F4H-1, the first aircraft to fly with such a system. Similar equipment is on the Navy's first weapon system, the A3J "Vigilante." This broad AiResearch systems capability is now being applied in the fields of military aircraft, commercial jet transports, missiles and submarines.

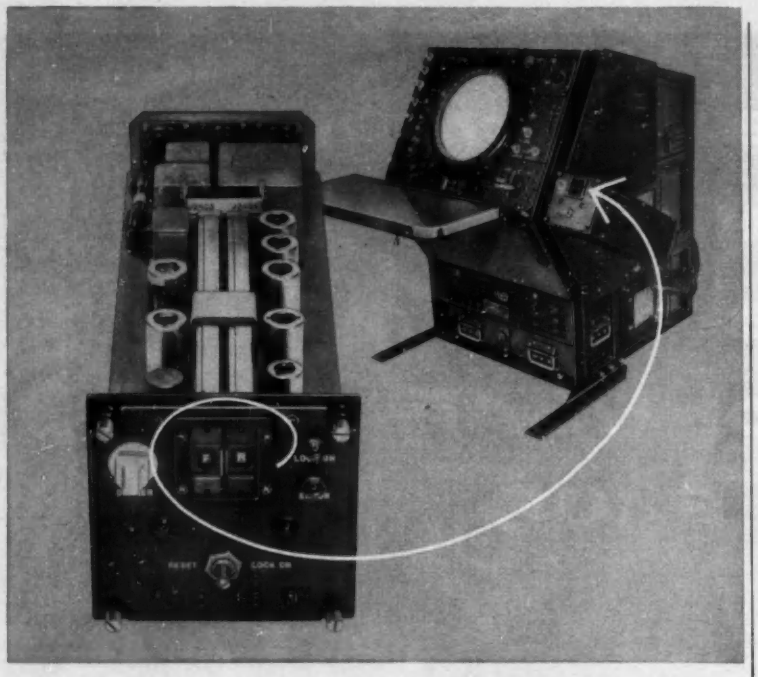
THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

CIRCLE 107 ON READER-SERVICE CARD



Union Indicators help Hazeltine radar-display unit identify aircraft

The little box on the right side of the radar-display unit above warns of approaching aircraft. IFF response is displayed by Alpha-Numerical Indicators, made by Union Switch & Signal. Hazeltine Corporation, Little Neck, N. Y., builders of this unit, chose Union Indicators for their supreme reliability, compact design, and for the other features below:

Two types of Data Display Indicators are made by Union Switch & Signal: Digital, displaying 10, 12, or 16 characters, and Alpha-Numerical, displaying up to 64.

Infinite Retentivity—Both indicators require power only during response time and retain data visually *and* electrically until a new code is transmitted.

Electrical and Visual Read-Out—Electrical read-out of data is provided in the same form as the input. Data can be read out on a continuous basis without erasing the stored information. Visibility of digital read-out is excellent, even when indicators are mounted in rows. Both indicators operate directly on binary codes on a null-seeking basis, eliminating need for external translation equipment.

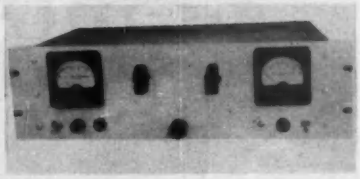
Write today for complete information on indicators and other electronic equipment manufactured by Union Switch & Signal.

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

CIRCLE 108 ON READER-SERVICE CARD

POWER SUPPLIES

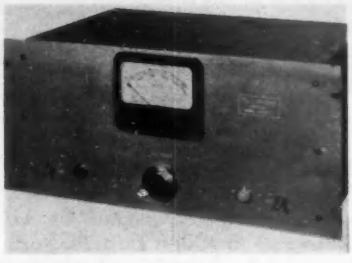


SUPER-REGULATED

An unusual new power supply, the Model S-325, brings the regulation and stability of laboratory reference supplies to the high-voltage ranges required by photomultipliers, klystrons, radiation counters, and cathode-ray devices. Low-priced and compact, the new supply can be used either as a bench or rack-mounted unit. So exceptional is its performance that the characteristics have been rated in parts per million rather than percentages.

Characteristics:
Line regulation: within 50 ppm
Load regulation: within 60 ppm
Ripple never more than 10 ppm
Output voltage: 500 to 2,500 volts
Output current: 0 to 10 ma dc
Price: $395
—N. J. E. Corp., Kenilworth, N. J.

Circle No. 235 on reply card



HIGH-VOLTAGE POWER

Use of temperature-regulated voltage standards, ac chopper amplifiers, high-gain dc amplifiers, and regulated dc filament voltages assures extremely stable performance in two new high-voltage power supplies. Output voltage ranges are 800 to 2,500 volts and 400 to 1,500 volts. Both types deliver an 8-ma output current, and both have a polarity-reversing switch. Applications include ion chambers, proportional counters, scintillation counters, etc.—The Victoreen Instrument Co., Cleveland, Ohio.

Circle No. 236 on reply card

NEW!

SMALL!

DELCO POWER TRANSISTOR

Designed for use where space and weight are restricting factors



MAXIMUM RATINGS	2N1172
Collector Diode Voltage	40 volts
Emitter Diode Voltage	20 volts
Collector Current	1.5 Amperes
Junction Temperature	95°C
TYPICAL CHARACTERISTICS (25°C)	
Max. Collector Diode Current I_{co}— V_{cb}=40 volts	50μ
Current Gain (V_{cc}= −2 volts, I_c=100 Ma)	70
Current Gain (V_{cc}= −2 volts, I_c=1A)	30
Saturation Resistance	0.3 ohms
Cutoff Frequency (Common Emitter)	25 kc
Thermal Resistance	7°C /Watt

The 2N1172 is a medium power transistor offering dependable operation in a new range of applications where space and weight have been a problem.

It's a mighty mite with more punch in a smaller package. The 2N1172, excellent for output use or as a driver for a very high power transistor, has already proved especially effective in DC amplifiers, voltage regulators, and as a driver for a high power stage in servo or other amplifiers.

This PNP germanium transistor is housed in a modified version of the JEDEC 30 package with a diamond shaped base for improved thermal conduction. It dissipates 2 watts at a mounting base temperature of 70 degrees centigrade. Available now in volume production—write today for complete engineering data.

DELCO RADIO

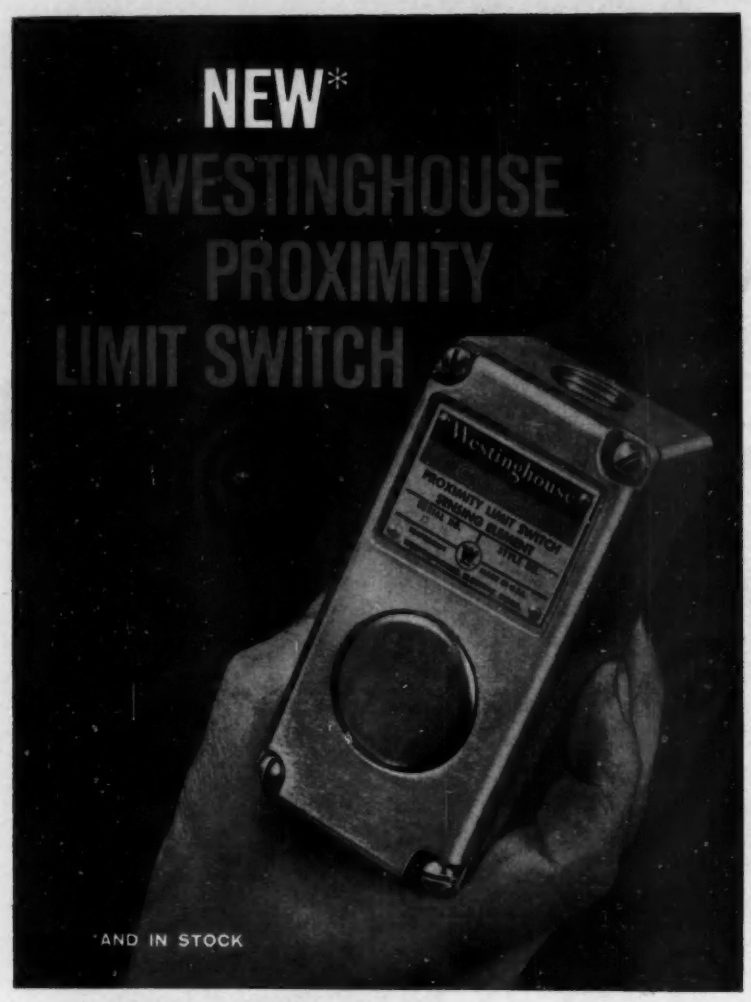
Division of General Motors
Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

CIRCLE 109 ON READER-SERVICE CARD



...WON'T WEAR OUT... NEVER NEEDS REPLACEMENT

No tubes . . . no moving parts to weaken and fail from wear . . . not affected by dust, dirt, oil mist or iron filings . . . will even operate under water . . . sensing heads available for distances of ½ inch and 2 inches . . . also for explosion-proof applications . . . corrosion and vibration resistant . . . won't spark, pit or wear, because there are no contacts.

Sure, they cost a little more initially. But we haven't seen the application yet where the new Westinghouse proximity limit switch can't pay for itself time and again through eliminated replacements and machine down time.

GET ALL THE FACTS about new Westinghouse proximity limit switches . . . see how and where they can benefit you. Write to Westinghouse Electric Corporation, Director Systems Department, 356 Collins Avenue, Pittsburgh 6, Pennsylvania. J-01011

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

CIRCLE 110 ON READER-SERVICE CARD

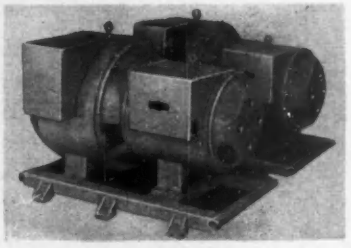
NEW PRODUCTS



MISSILE BATTERY

Well-suited for missile telemetering applications, this new battery contains 18 15-amp-hour, high-rate, silver-zinc cells and five 10-amp-hour cells providing normal discharge voltages of 27.0 and 6.6 volts. Weight is 26 lb and dimensions are 6.75 in. high by 10.187 in. in diameter. The unit has been built to operate at altitudes up to 200 miles and at temperatures ranging from 0 to 125 deg. F. Other features include a one-year shelf life and a 10-cycle rechargeability.—Yardney Electric Corp., New York, N. Y.

Circle No. 237 on reply card



SYSTEMS APPROACH

The frequency-converting system shown here consists of two 50-kw motor-generator sets for 60- to 400-cycle conversion, together with a control panel that contains all necessary generator and motor controls. A static exciter and magnetic-amplifier voltage-regulator unit controls the 400-cycle output voltage. The motor-generator sets are induction-motor-driven at 1,714 rpm.—Kato Engineering Co., Mankato, Minn.

Circle No. 238 on reply card

PLUS . . .

(239) **Electronic Measurement Co., Inc.**, Eatontown, N. J., has announced a new 6-kva **voltage regulator** for 110-

CIRCLE 111 ON READER-SERVICE CARD →

Smoothing out Level Measurement Problems with the Robertshaw Level-Tel

PROBLEM: How to measure bin level changes *accurately* in hot, hard-to-handle, extremely abrasive materials.

SOLUTION: The Robertshaw Level-Tel continuous level indicator.

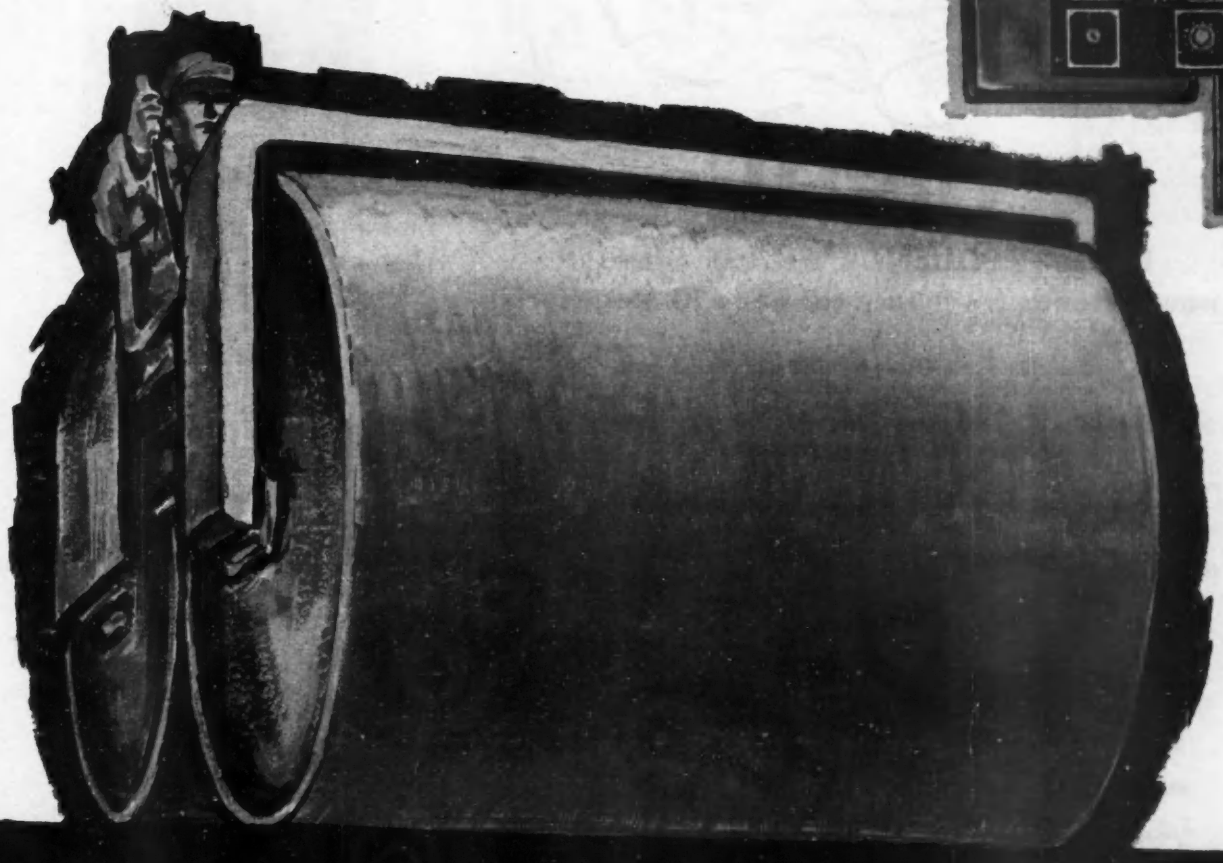
EXAMPLE: The four hot gravel bins at the Valley Asphalt Plant, City of Los Angeles, are relatively inaccessible, too hot to touch and contain no open ports. Reaching deep into each of the bins, a probe specifically designed for rugged duty continuously detects the changing gravel level and, by means of a simple capacitance bridge, relays the information to the plant control room. Previously, the operator had no way of knowing accurately the gravel level in each bin prior to mixing with liquid asphalt. Blacktop from the plant is used for road repair throughout California's burgeoning San Fernando Valley.

Installed two years ago, the Robertshaw continuous level measuring system has required no maintenance, while performing with extreme accuracy. According to Valley Plant engineers, the Level-Tel system has speeded up plant operation, reduced bin overflow and enabled them to determine easily the best time to change formulations.

SUGGESTION: The Valley Asphalt Plant operation is just one of many possible Level-Tel applications. If you are engaged in processing, manufacturing, refining or mining, there's a Robertshaw quantitative measurement and control system to fit your specific requirements. Write for Bulletin RF-583-5.

Aeronautical & Instrument Division, Robertshaw-Fulton Controls Company, Santa Ana Freeway at Euclid Avenue, Anaheim, California.







DIEHL*

HIGH FREQUENCY PHASE SHIFTER

now extends frequency range to 10 Megacycles

The unique characteristics of these newly developed units suggest such interesting fields of application as:

Color TV Test Equipment **Direction Finding Equipment**
Missile Tracking **Standard Time Signal**
Communications **Computers (Pulse Generating)**

While accuracies of these Phase Shifters vary with the frequencies, the error at 2 megacycles is less than 30 minutes. Dual channel or single channel units can be provided. Outputs terminate in Cathode Follower circuits, with output impedances of 50 or 500 ohms. Transistorized units can be developed for special requirements.

Write for detailed specifications for the frequency to suit your application.

Diehl* SINGER†

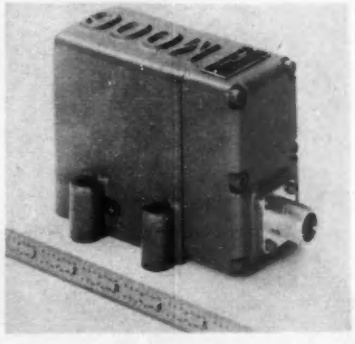
DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.
other available components
• AC SERVOMOTORS • AC SERVOMOTORS WITH AC TACHOMETERS • DC SERVO SETS
• AC SERVOMOTORS WITH DC TACHOMETERS • AC AND DC TACHOMETERS • RESOLVERS
*A Trademark of DIEHL MANUFACTURING COMPANY †A Trademark of THE SINGER MANUFACTURING COMPANY

CIRCLE 112 ON READER-SERVICE CARD

or 220-volt lines. . . . (240) A packaged 50-kw, 400-cycle **motor-generator set** for missile or jet ground-support equipment is available from **Electric Machinery Mfg. Co.**, Minneapolis, Minn. . . . (241) From **Trans Electronics, Inc.**, Canoga Park, Calif., comes word of a new 0-to-35-vdc **supply** combining a tube amplifier with transistor series elements.

Circle No. 239, 240 or 241 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS



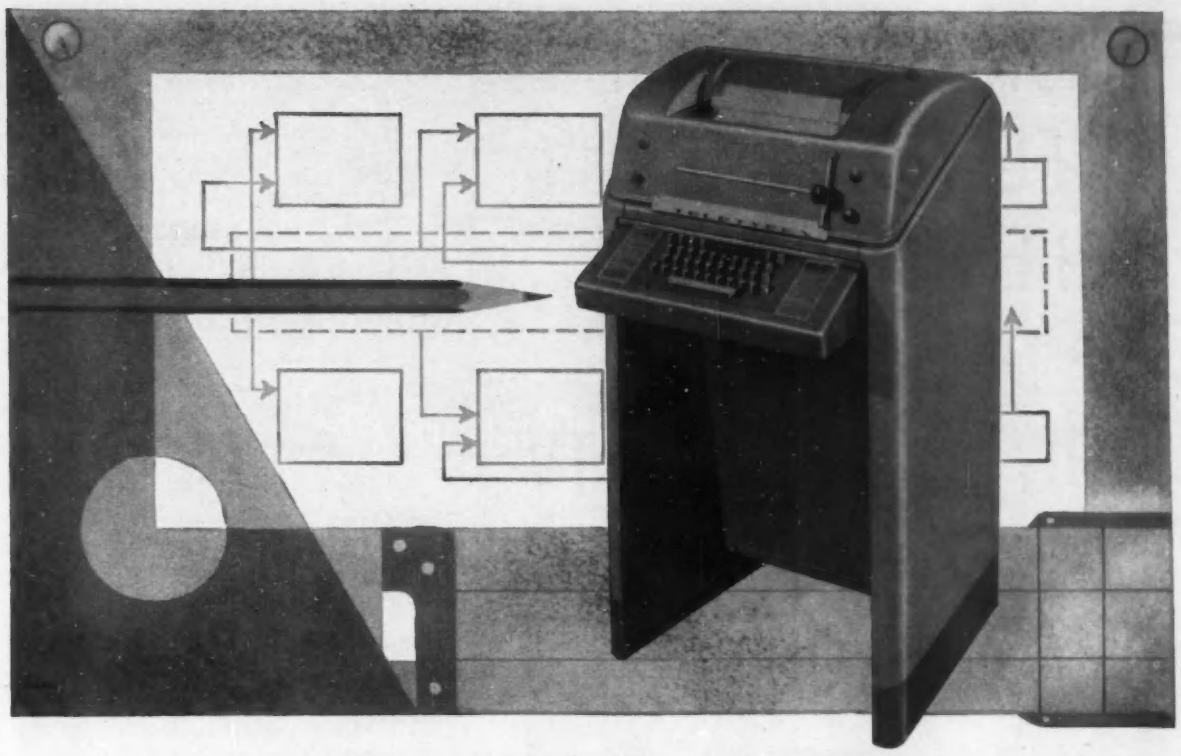
DESIGNED FOR INDUSTRY

Pictured is one of four new flow-control valves designed specifically for industrial hydraulic control systems. Called the Series 71, these valves operate on the proven two-stage, force-balance feedback principle and feature a large built-in, field-replaceable filter. Stock sizes handle 1, 2.5, 5, and 10 gpm with a 1,000-psi valve drop and 20-ma input. System pressures are from 500 to 4,500 psi. Applications are in automatic machine tools, positioning and transfer devices, grading machines, and power steering systems. — Moog Valve Co., East Aurora, N. Y.

Circle No. 242 on reply card

CRYOGENIC BUTTERFLY

Designed for pneumatic, hydraulic, electric, or manual actuation, a new line of low-temperature butterfly valves features positive sealing at temperatures of minus 320 to plus 165 deg F, against pressures of 4 to 200 psi. Other special features include rapid response, high capacity, low pressure drop, and



Put Teletype dependability into your system plan

Dependability . . . the inherent ability to stand up under the grueling punishment of continuous operation . . . is a Teletype tradition. This dependability has been demonstrated by years of service in such demanding fields as commercial telegraphy, press networks, railroads and airlines, stock market quotation and securities purchase systems, weather data collection, and military communications.

Model 28 Printer. If your system requires a printer for communications or readout, the Model 28 combines traditional Teletype dependability with exceptional flexibility to suit a wide variety of requirements.

Features

Type box printing, with interchangeable type boxes—removable in seconds, without tools.

Stunt Box devoted to nontyping operations—a built-in, high-capacity "little black box" for handling signaling, switching and control assignments, either locally or remotely.

Friction feed for plain paper—or sprocket feed for printed forms.

Horizontal tabulator . . . form-out . . . back space and reverse line feed . . . automatic carriage return and line feed.

Can be equipped to accommodate parallel-wire input.

Specifications

Operates on 5 level Baudot code, with operating speed of 10 characters per second.

Signal requirements, 20 or 60 ma D.C. line current.

If you'd like detailed information about the Model 28 printer—or our tape punches, readers, and composite set—write to Teletype Corporation, Dept. 22D, 4100 Fullerton Avenue, Chicago 39, Illinois.

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CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

BLONDER-TONGUE OFFERS A FREE SURVEY TO DEMONSTRATE HOW INDUSTRIAL TV CAN BENEFIT YOU

Industrial television (closed circuit TV), the newest means of visual communication, is now increasing profits and efficiency for industry, science and education. Undoubtedly, there is some area of your present operation (continuous process control, quality control inspection, data transmission, plant or property protection, monitoring gauge and instruments, safety, dispatching, etc.) that can be improved by the use of industrial TV. The question is—what area?... How will it be benefited? . . . and what is the cost?

Blonder-Tongue and its nationwide staff of specialists eliminate all the guess-work in industrial television by offering you a free survey in your plant, office, etc. to demonstrate where and how industrial television will benefit you, what an installation involves and the cost. With industrial TV increasing efficiency at companies and institutions similar to your own, you can't afford to miss this opportunity to find out at no risk, no obligation what industrial TV can do for you.

Many leading organizations now rely on Blonder-Tongue industrial TV systems. Included among them are U. S. Steel, Sharon Steel, Southwestern Portland Cement, Johnson & Johnson, E. I. Dupont, General Motors, Brunswick Pulp and Paper, Union Carbide, Douglas Aircraft, Public Service of New Jersey, Los Angeles Dept. of Water and Power, St. Mary's Hospital, Albert Einstein Medical Center, West Phoenix High School and many others.

wire—phone or write today for a free survey

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A completely automatic Blonder-Tongue industrial TV system (compact, rugged camera; automatic light compensator; TV monitor) providing quality pictures can be installed for less than $2,500.00.

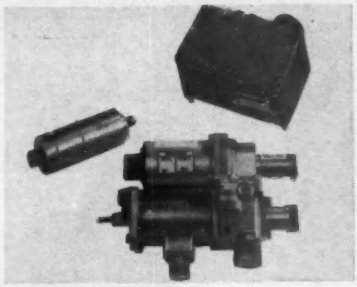


CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

short installation length. Sizes qualified for missile applications have 4-, 6-, 7-, 9-, and 11-in. inside diameters. —B. H. Hadley, Inc., Pomona, Calif.

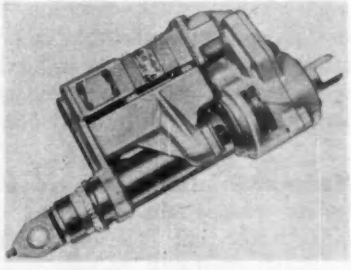
Circle No. 243 on reply card



THRUST CONTROL

This new electrohydraulic thrust control, a closed-loop device for metering hydrogen peroxide to auxiliary rocket engines on manned aircraft or guided missiles, weighs 7.3 lb and includes a magnetic-amplifier, pressure transducer and metering valve assembly. With the device, thrust level can be varied as a function of an external electrical command signal. Error between thrust-chamber pressure and the command signal is electrically amplified to actuate a fuel-metering valve.—Bendiz Aviation Corp., South Bend, Ind.

Circle No. 244 on reply card



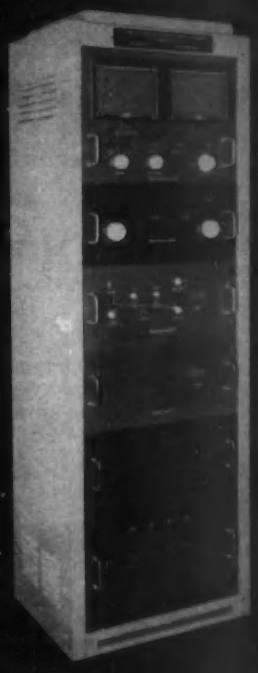
LOW WEIGHT, HIGH LOAD

This new linear power actuator, Model D-2810, was originally designed for positioning a control surface on a military aircraft. However, it is also well-suited for missile, ordnance, marine, and industrial applications. Features include an electromagnetic clutch-brake that minimizes overtravel and provides irreversibility to an applied load of 28,000 lb; an adjustable position transmitter for operation in a closed-loop circuit; micro-adjustable

U.S. Army Signal Laboratory designs computer to measure wind effects on missile launchings...

...and Vernistat* is there!

Near-surface winds at a launching can easily force a missile off course, with the result that the missile lands outside the target area. To counter the effect of such surface winds, the missile launcher is tilted to a corrective angle. Calculating the wind effect and the proper angle of tilt of the launcher, however, can be mathematically quite complex and a time-consuming operation. The United States Army Signal Research and Development Laboratory at Ft. Monmouth, New Jersey has developed a compact computer for this job. Quickly and accurately, from pilot balloon data, the computer calculates both wind displacement on the missile and the proper tilt of the launching stand.





Since different types of pilot balloons have different rates of rise, and wind effects vary with each type of missile, signal inputs to the computer must be easily and quickly adjusted. That's one reason why USASRDL engineers chose two Vernistat Adjustable Function Generators. Only seconds are required to change from one function to another.

Doesn't Vernistat thinking belong in your system design too?

Nonlinear servo system and computer inputs are easily adjusted with the Vernistat Adjustable Function Generator. In addition, the Function Generator enables nonlinear system characteristics to be corrected with a minimum of time and effort. The Function Generator, a variation of the unique Vernistat a. c. potentiometer, can generate mathematical or empirical functions, even those with multiple slope reversals. The function is displayed graphically on a 6 x 8 inch panel which allows for instant visualization and adjustment.

Connected to a 34-pole printed circuit switch are 101 voltage levels. Any of the 34 poles can be connected to any desired voltage level to within 0.5%. The Generator's X-axis represents shaft position of an interpolating Vernistat potentiometer, and the Y-axis represents percentage of input voltage.

Linear interpolation between each adjacent pair of the 34 selected voltage levels is provided by a Vernistat interpolating potentiometer. Minimum slope of voltage output curve is zero, with a 20-volt maximum between adjacent poles. Maximum output impedance is 130 or 470 ohms. Units are designed for operation over a wide range of frequencies.

• • •

Write now for full details on Vernistat Adjustable Function Generators, a. c. potentiometers, and variable ratio transformers.

***vernistat®** — a new design concept that unites in one compact device the best features of both the precision autotransformer and the multiturn potentiometer.*

Perkin-Elmer *Corporation*

vernistat DIVISION

765 Main Avenue, Norwalk, Conn.

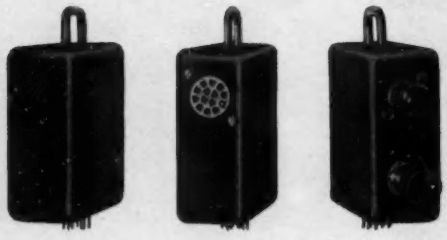
CIRCLE 115 ON READER-SERVICE CARD

NEW EECO

Transistorized

DECADES

for extremely reliable operation in the 0 to 250 kcs range



ONE-THIRD ACTUAL SIZE



APPLICATIONS

New EECO N-Series Transistorized Decades are miniaturized plug-in units designed for reliable pulse counting and frequency division in the frequency range of 0 to 250,000 pulses per second.

FEATURES

- Small, compact size.
- Simple power supply requirements (for example, Models N-101 and N-102 require only −12 volts).
- Low power consumption.
- Compatible with EECO T-Series circuits.
- Auxiliary 9-step staircase output available.
- Plug into standard 9-pin miniature socket. (Some models require special 13-pin socket, furnished with each such unit.)
- Pin connections arranged for in-line wiring of power and grounds.
- Extreme reliability, due to saturation techniques and consistent derating of component tolerances.

WIDE SELECTION

EECO N-Series plug-in Decades are available in the following standard models:

MODEL	DESCRIPTION
N-101	No readout.
N-102	Incandescent readout.
N-104	Incandescent readout (remote). Typically a projection readout module.
N-105	Nixie readout. (Can be cabled to remote Nixie.)
N-106	Nixie readout with preset control switch. (Can be cabled to remote Nixie.)
N-107	Incandescent readout with inputs for external preset control.
N-108	Incandescent readout (remote) with inputs for external preset control.

TYPICAL SPECIFICATIONS

The N-102 Transistorized Decade, which includes visual readout of numerals 0 through 9 displayed vertically and illuminated by incandescent lamps, is identical electrically with Model N-101. Abbreviated specifications are as follows:

INPUT

Minimum Trigger Input: (0-100 kcs): 7 volts pos. pulse or step at 0.5 μsec. rise time. (100 kcs to 250 kcs): 7 volts pos. pulse or step at 0.2 μsec. rise time.

Max. Operating Frequency: 250 kcs.

Input Impedance: 470 μμfd. capacitance, max.

D C Reset input is provided (normally supplied by EECO T-129 DC Reset Generator).

OUTPUT (No Load)

Amplitude: 8 volts, peak to peak.

Output Levels: (N/10) and (N/10)′: −11 volts DC and −3 volts DC, nom. Staircase: −11 volts DC to −3 volts DC in 9 steps.

Rise Time: (N/10): 0.5 μsec.; (N/10)′: 0.5 μsec.

Load: Typical, one N-Series Decade or one T-Series flip-flop. (Load information available on request.)

OPERATING TEMPERATURE RANGE: −45°C to +65°C.

SIZE: 1-5/32" wide x 2-3/32" deep x 3 7/8" seated height (including handle). Dimensions are exclusive of external addenda found on external preset and Nixie models.)

Additional information on N-Series Transistorized Decades and other EECO products available on request.

ENGINEERED ELECTRONICS COMPANY

(a subsidiary of Electronic Engineering Company of California)

506 East First Street • Santa Ana, California

CIRCLE 116 ON READER-SERVICE CARD

NEW PRODUCTS

end fittings; and thermal overload protection. Normal load is 7,500 lb; maximum operating load, 15,500 lb. The unit travels its 2.5 in. stroke at the rate of 0.14 in. per sec.—Hoover Electric Co., Columbus, O.

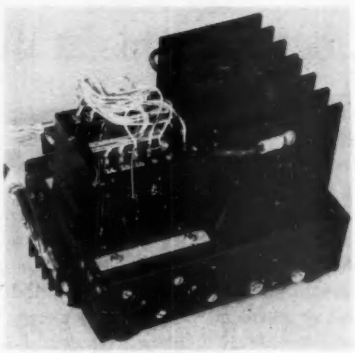
Circle No. 245 on reply card

PLUS . . .

(246) A permanent-magnet **stepper motor**, developed by **American Electronics, Inc.**, Los Angeles, Calif. provides a minimum stepping rate of 90 pulses per sec in random pulse direction. . . . (247) **Bettis Corp.**, Houston, Tex., announces a new line of **valve actuators** that convert 3 to 15 psi instrument air to high torque operation for throttling or positioning plug valves, ball valves, and other 90-deg rotation devices. . . . (248) **Gate valves** for handling liquid oxygen and other cryogenics at temperatures down to minus 320 deg F are now available from **Koehler Aircraft Products Co.**, Dayton, O.

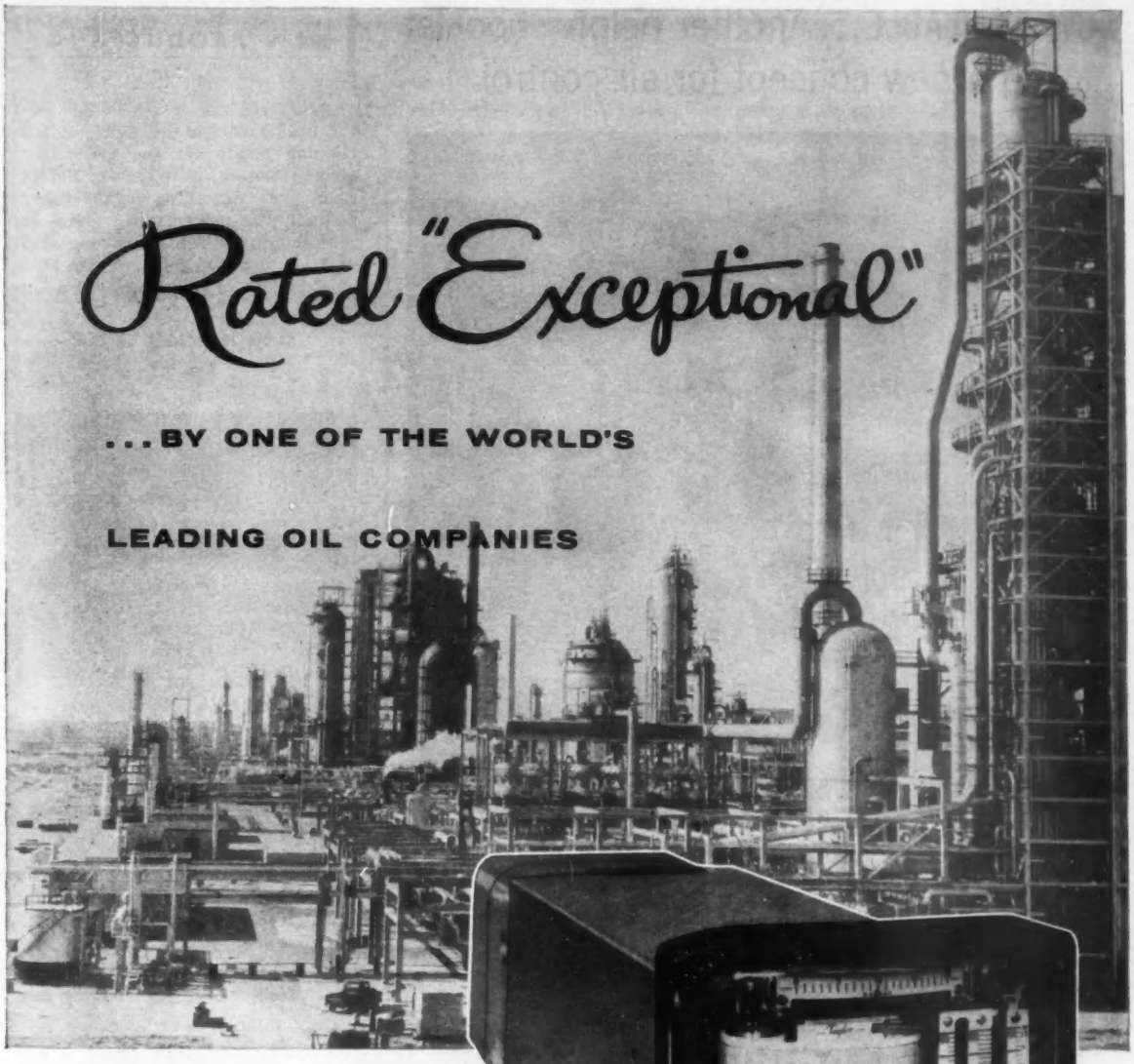
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COMPONENT PARTS



FOR STATIC CONTROL

A brand-new magnetic amplifier (top left on the chassis above) is designed specifically to control the firing of "solid-state thyratrons" such as GE's controlled rectifier and Westinghouse's Trinistor. A compact 3-in. cube, the unit features five isolated input windings, operates on 120-volt, 60-cycle current. In the particular application shown here, the amplifier operates two controlled rectifiers mounted in



An internationally famous oil company recently carried out exhaustive tests on the Taylor 90J TRANSCOPE* Recorder. This particular company is continually testing and evaluating instruments from all over the world.

In the opinion of the qualified specialists of this world-famous company, the performance of the 90J Recorder was outstanding. In fact they were so impressed that they established a *new classification* . . . they rated it "exceptional".

Experience with this instrument has inspired the statement, "No other recorder puts so many features in so little panel space". And it's so easy to prove — make arrangements with your Taylor Field Engineer — to put a 90J TRANSCOPE Recorder on test. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.

*Reg. U.S. Pat. Off.

Look to Taylor for **VISION . . . INGENUITY . . . DEPENDABILITY**

Taylor Instruments MEAN ACCURACY FIRST

CIRCLE 117 ON READER-SERVICE CARD

NOW AVAILABLE... Another helpful booklet on a new concept for air control



A comprehensive discussion of the 4 basic principles involved in designing an economical "control by air" system for industrial machines and processes.

Westinghouse Air Circuitry means the *control by air* rather than the mere use of it. It deals with the interlocking, sequencing, timing and segregation of events to obtain automatic or semi-automatic control. It is applicable to any automation problem on any industrial machine . . . in any industrial process. The equipment involves uncomplicated mechanical devices with few moving parts. Any mechanic can easily install and service a Westinghouse Air Circuitry system.

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TITLE.....

FIRM.....

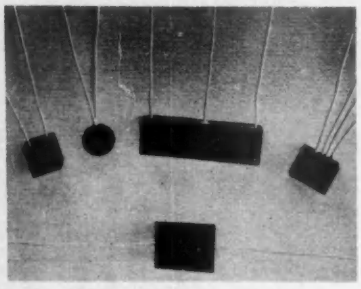
ADDRESS.....

CITY..... **STATE**.....

CIRCLE 118 ON READER-SERVICE CARD

the heat sinks on the right. A self-clipping action on the gate signal makes it impossible to damage the rectifier gate. According to the manufacturer, the new device is ideal for static control systems involving loads of a few watts to more than 3 kw.—Control Div. of Magnetics, Inc., Butler, Pa.

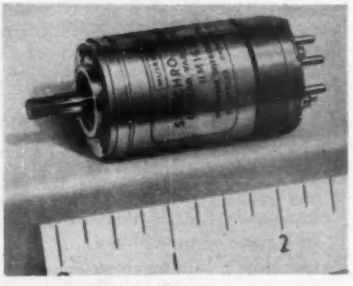
Circle No. 249 on reply card



SPACE SAVERS

Designed for limited-space applications, the ABC series of miniature, low-cost selenium rectifiers is available in a wide range of voltages and currents for use in half-wave, full-wave, single-, or three-phase rectifier circuits. Heading the list is the type ABA, a 130-volt, 20-ma unit that is ideal for rechargeable battery-operated appliances.—Radio Receptor Co., Inc., Brooklyn, N. Y.

Circle No. 250 on reply card

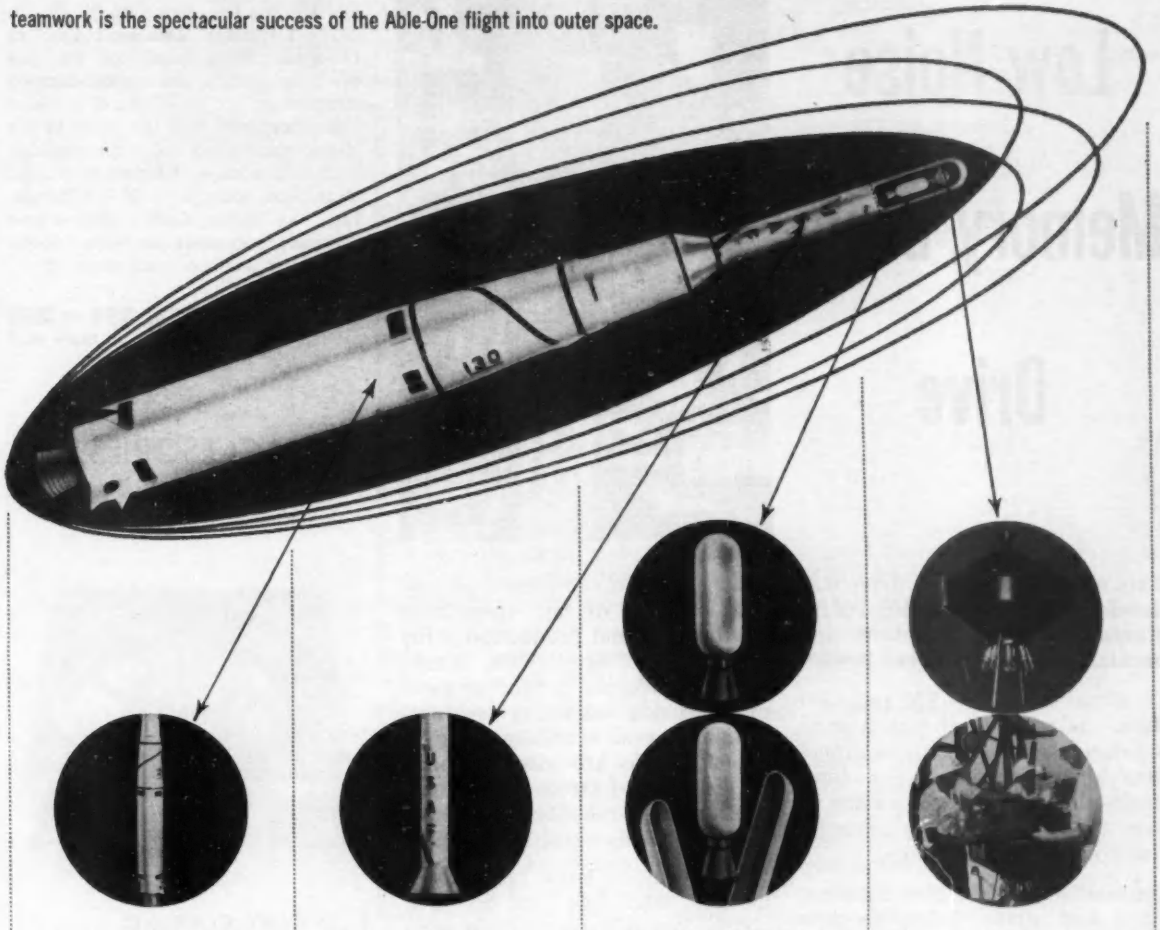


SIZE 11 "LINVAR"

Housed in a standard Bu-Ord Size 11 synchro frame, this lightweight instrument provides a voltage output proportional to the angular displacement of its rotor. A special patented design of the rotor and stator laminations produces a linearity within ¼ percent over its full range of travel, which is plus or minus 85 deg from the zero output position. Models are

Able-One... a new apogee in scientific teamwork!

Preparation and execution of an undertaking such as the United States' IGY space probe demanded the participation and exceptional efforts of 52 scientific and industrial firms and the Armed Forces. The Advanced Research Projects Agency and the AFBMD assigned Space Technology Laboratories the responsibility for the project which was carried out under the overall direction of the National Aeronautics and Space Agency. One measure of this teamwork is the spectacular success of the Able-One flight into outer space.



1st stage: Vehicle, Douglas Aircraft **Thor** IRBM; propulsion, Rocketdyne; airframe, control, electrical and instrumentation, Douglas Aircraft; assembly, integration, and checkout, Douglas Aircraft.

2nd stage: Propulsion system and tanks, Aerojet-General; control, electrical, instrumentation, accelerometer shutoff, and spin rocket systems, STL; assembly integration, and checkout, STL.

3rd stage: Rocket motor, U. S. Navy Bureau of Ordnance and Allegheny Ballistic Laboratory; structure and electrical, STL; assembly, integration, and checkout, STL; ground testing, USAF's Arnold Engineering Development Center.

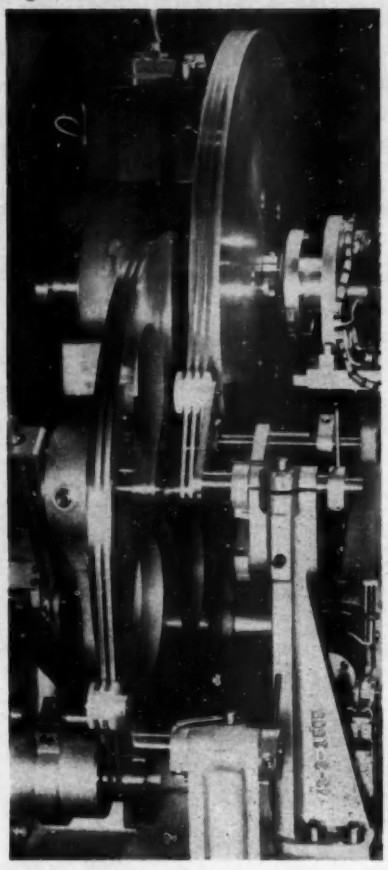
Payload: Design and production of **Pioneer**, the payload of the Able-One vehicle, was conducted by STL in addition to its overall technical direction and systems engineering responsibility of the Air Force Ballistic Missile Division project. This highly sophisticated package included a NOTS TV camera and transmitter and Thiokol rocket motor.

Inquiries concerning openings on our staff will be welcomed by

Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California.

Call on Clevite's Computer Know-How

NEW Low-Noise Memory Drum Drive



This stainless steel belt drive was developed to reduce the noise of instantaneous speed variations and backlash inherent in gear drives.

In actual tests with FM recorded data, the noise level was four to six decibels lower than the finest gear drives available for comparison. Signal-to-noise ratios of over 60 db (with noise cancellation) have been measured.

Unusually durable, this stainless steel belt drive holds its low noise level for years.

While this drive is for a special-purpose magnetic memory drum, similar drives can be designed for any memory drum or tape transport.

This precision component is just one example of the specialized engineering and production skills to be found at Clevite, Texas Division. We are producing complete analog computer systems with an overall accuracy of 1 part in 6000. We are also equipped to design and build sub-systems and computer-controlled servo systems to any specification.

If you want to know more about us and what we can do, just write. We will be glad to send you our brochure describing facilities or arrange for an appointment at your convenience.

Clevite Corporation, Texas Division, 9820 South Main Street, Houston 25, Texas

Other Divisions of Clevite Corporation serving industry and defense:

Brush Instruments • Cleveland Graphite Bronze • Clevite Electronic Components • Clevite Harris Products • Clevite Limited • Clevite Ordnance • Clevite Research Center • Clevite Transistor Products • Intermetall G.m.b.H.

CLEVITE CORPORATION

TEXAS DIVISION

CIRCLE 119 ON READER-SERVICE CARD

available for 115- and 26-volt operation at 400 cps.—Muirhead Instruments, Ltd., Stratford, Ont., Canada.

Circle No. **251** on reply card

PLUS . . .

(252) Fifty-eight additional types of low-current **silicon rectifier cells** have been put in production by the **General Electric Co.**, Syracuse, N. Y. . . . (253) **Daystrom Transicoil Div. of Daystrom, Inc.**, Worcester, Pa., has just announced a new **inertial-damped servomotor.** . . . (253) The first silicon **logic transistors** with the speed of the fastest germanium types are available from **Transitron Electronic Corp.**, Wakefield, Mass. . . . (255) **Ultronix, Inc.**, San Mateo, Calif., offers a new **trimming potentiometer** with a maximum temperature coefficient of 25 ppm per deg C.

Circle No. **252, 253, 254** or **255** on reply card

ACCESORIES & MATERIALS



LOW-COST COOLING

Called the Muffin, this new 60-cycle fan will deliver up to 100 cfm of free air. It features an inside-out motor and integral rotor-impeller combination. Life expectancy is 3 to 5 years for continuous-duty operation within the temperature range of 40 to 110 deg F on a 105-to-120-volt, 60-cycle line. Overall dimensions are 4-11/16 in. sq by 1½ in. deep. The highly efficient shaded-pole motor draws only 13 watts maximum. In quantity lots, the fan will sell for less than $8.—Rotron Mfg. Co., Inc., Woodstock, N. Y.

Circle No. **256** on reply card

CAN SYNCHROS BE MOISTURE-PROOFED?



Thanks to the special materials and construction of improved Ketay synchros, the moisture-resistance standards of Mil Spec 20708 (superseding all previous specifications) can be met *or exceeded.*

Many of these special materials and design features are exclusive with Ketay . . . the only source currently manufacturing and shipping a wide range of the new Mil-type synchros.

Stainless steel housing, shafts, and bearings . . . stators potted in anti-fungus epoxy resin . . . hermetically sealed windings . . . thru-bore construction for fewer parts and less space where moisture can collect . . . these and a variety of other Ketay features all give extra protection against moisture damage.

For high performance and dependability, despite extremes of humidity and temperature, specify Ketay synchros and other precision components, available in production quantities in sizes from 8 to 23. Sixty cycles per second units are available as small as size 15. Units one or more sizes smaller and lighter than previously required can often be used, because of Ketay's superior accuracy. Units of 3′ and 2′ accuracy are available for immediate delivery.

Ketay engineers are working with manufacturers whose prototype systems have unusual environmental and accuracy requirements. Call or write for help in solving your special problems.

Ketay precision components:
SYNCHROS
RESOLVERS
POTENTIOMETERS
SERVO MOTORS
TACHOMETERS
SERVO AMPLIFIERS
GYROMECHANISMS
Catalogues available

NORDEN Division of United Aircraft Corporation

KETAY DEPARTMENT, Commack, Long Island, N.Y.

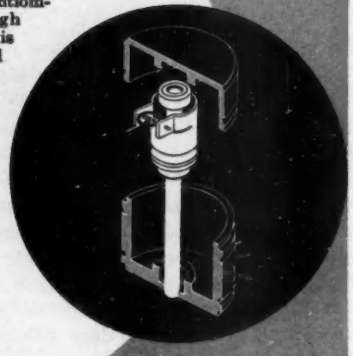
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New! "hi-temp" pot innovation!

KINTRONIC "UNITIZED" DYNAMIC BALANCE CONTACT ARM ASSURES RELIABILITY EVEN AT 225 C°!



Now "Unitized" construction provides greatest resistance to *all* environmental extremes! Kintronic's new design means *extremely* high temperature performance added to the advanced design abilities of Dynamic Balance Precision Potentiometers! Kintronic's reliability through severe shock, vibration and acceleration is acknowledged fact . . . today specified for innumerable military and commercial applications. When these new high temperature operating characteristics are added, Dynamic Balance Potentiometers permit much wider latitude of design plus assured equipment dependability.



New "Unitized" arm . . . engineered for maximum simplicity, efficiency, reliability:

- All stainless steel metal parts
- Matched coefficient of expansion—all metal and insulating components
- Glass to metal seal terminals
- Spring loading

We suggest you also consider these single turn precision potentiometer characteristics:

- Exclusive Dynamic Balance—arm balanced on shaft; contact assembly balanced on arm.
- 5,000,000 cycle life
- 2,000 cycle life at 30 G's
- Linear or functional windings—0.2% maximum standard linearity, 0.1% maximum standard linearity for larger sizes
- Rotational speeds to 3,500 R.P.M.

Write for complete specifications for our 1000 AH Series

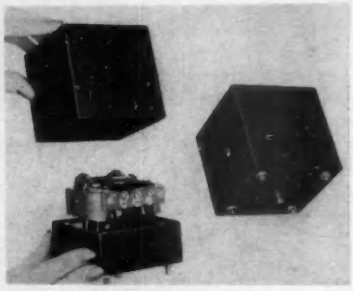
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CHICAGO AERIAL INDUSTRIES, INC.

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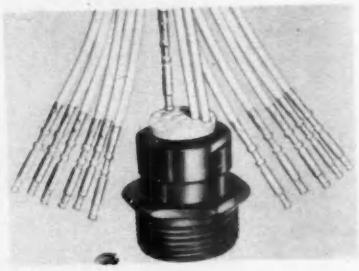
NEW PRODUCTS



SHIELDS CUT COSTS

A new Netic CoNetic magnetic shield permits the use of lower-cost shaded-pole motors in some servo and instrument applications by reducing the radiated field to under 5 gousses.—Perfection Mica Co., Chicago, Ill.

Circle No. 257 on reply card



SIMPLIFIES ASSEMBLY

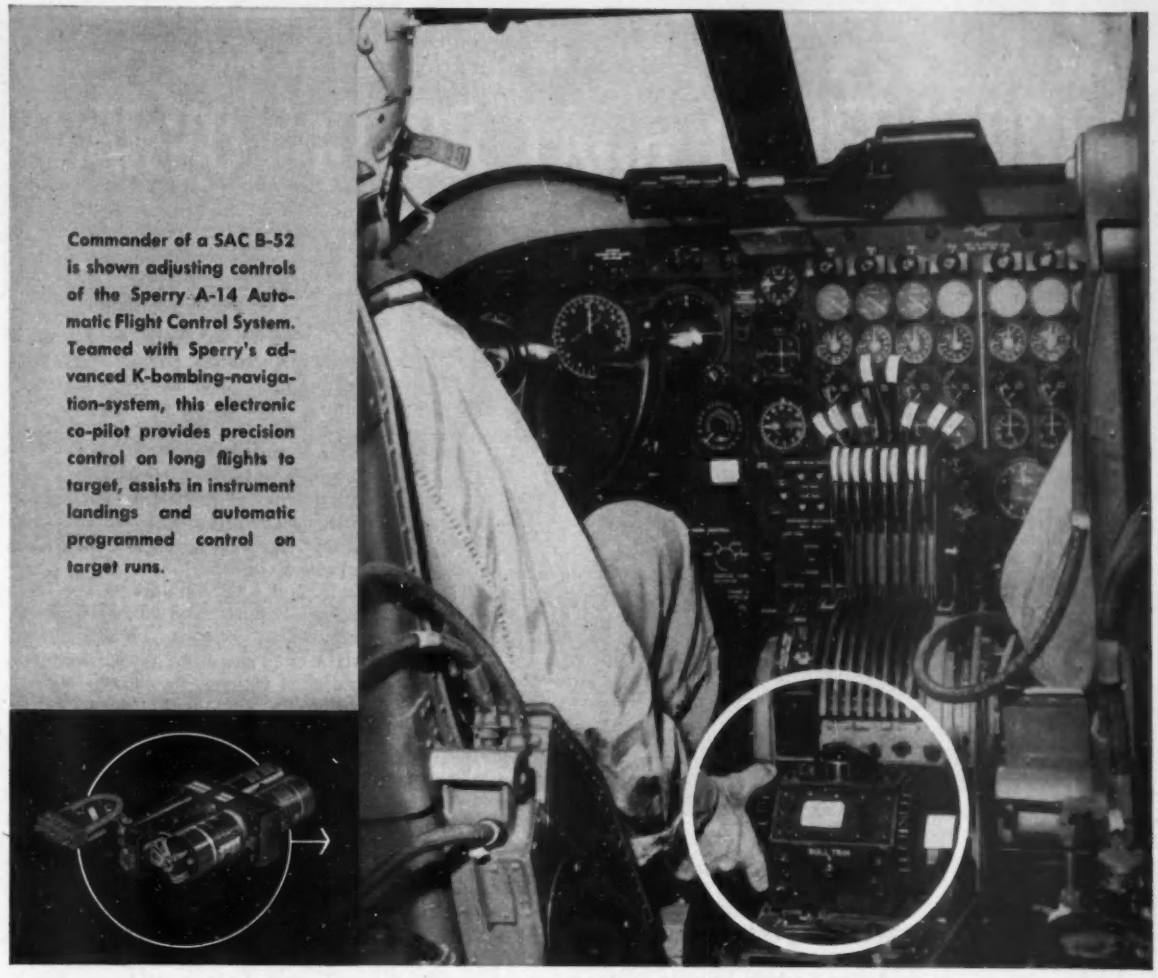
This new push-in contact insert permits high-speed wire terminations of great reliability. Contacts are crimped outside the connector; a cross hole in each contact facilitates inspection of the crimp before insertion. A special hand-tool is available for inserting the contacts into the premounted resilient insulation.—The Pyle National Co., Chicago, Ill.

Circle No. 258 on reply card

IMPROVED RESPONSE

Two new types of cryostat cooling systems boost the sensitivity and spectral response of infrared detector units used on missiles. Specifically, the systems cool the semiconductor elements that detect infrared radiation from the missile's target. One system uses liquid nitrogen at low pressure; the other uses high pressure nitrogen gas. Both are capable of maintaining a steady temperature of minus 300 deg F.—The Garrett Corp., Los Angeles, Calif.

Circle No. 259 on reply card



Commander of a SAC B-52 is shown adjusting controls of the Sperry A-14 Automatic Flight Control System. Teamed with Sperry's advanced K-bombing-navigation-system, this electronic co-pilot provides precision control on long flights to target, assists in instrument landings and automatic programmed control on target runs.

servo assist for sperry's electronic co-pilot

When the commander of a B-52 gives his Stratofortress the order to execute this or that maneuver, the control system of his "electronic co-pilot" automatically applies just the right force on the control surfaces to obtain the desired maneuver under the prevailing flight conditions. That's automatic flight control at its finest!

Daystrom Transicoil helps provide the calculated muscle for this flight system in the form of servo controlled pitch, roll, and yaw follow up; coordination integrator; and pitch integrator. Only the highest level of accuracy, performance, and reliability will do . . . for you, for us.

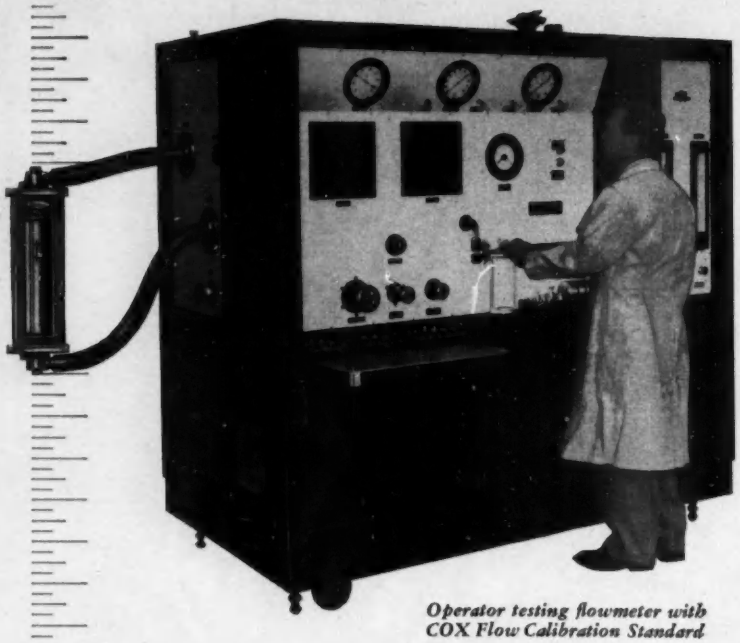
The engineering and manufacturing assistance you need to turn modern system requirements into optimized working sub-systems and assemblies is the very basis of our business. Contact us direct or through our local representative. Check into our 24 Hour Service on servo motors and generators. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Montgomery County, Pennsylvania. (Phone: JUNO 4-2421)

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CIRCLE 122 ON READER-SERVICE CARD

How UNION CARBIDE Verifies Flowmeter Accuracy



Operator testing flowmeter with COX Flow Calibration Standard

Periodic checking of liquid flowmeters at the huge Oak Ridge, Tennessee nuclear facility presented a problem to the Union Carbide Nuclear Company, operators of the facility. Checking the instruments required a known standard against which they could be evaluated. Using other flowmeters as masters was of questionable value as they too were subject to the same variables of wear, temperature changes, and viscosity shifts as were the instruments under test.

Union Carbide solved the problem by using a *COX Flow Calibration Standard* (Type 315), the same as those used by flowmeter manufacturers for original instrument calibration. It gives them a *primary standard* of their own — assuring accurate flow measurements that can be correlated with measurements by the National Bureau of Standards.

Costly? Not as much as you'd think for a *primary standard*. And the time normally spent on rechecking, evaluations, and analyzing test data was eliminated.



If you make or use flow measuring devices you will be interested in our new Technical Bulletin on *COX Flow Calibration Standards*. Write to: *Cox Instruments Division, George L. Nankervis Company, 15400 Fullerton Avenue, Detroit 27, Michigan.*

IF IT'S WORTH MEASURING
It's worth measuring accurately 7392

COX Instruments

CIRCLE 123 ON READER-SERVICE CARD

WHAT'S NEW

(Continued from page 66)

small tools and standard machines. It will be six to 12 months, the survey says, before builders of the big systems feel the difference. The same goes for the electrical industry; here, too, large equipment defers to appliances.

New Companies in the Field

Unholtz-Dickie Corp., organized by former executive engineers of MB Mfg. Co. to deal solely in vibration problems—in Hamden, Conn. Its services will cover fatigue, shock and shake testing, design for dynamic loads, suspension systems, noise control, and equipment and controls associated with dynamic testing. John A. Dickie, formerly general manager of MB and a pioneer in vibration work, is president, and Karl Unholtz, a specialist in aircraft flutter and vibration testing and control systems, who had been MB's chief engineer, is vice-president and chief engineering officer.

Plug-In Instruments, Inc., which is applying the plug-in, modular-construction concept to controllers, ratio computers, carrier amplifiers, servo-amplifiers, indicators and recorders, delay networks and relays, power supplies, and motor-protection devices—in Nashville, Tenn. Standard Plug-In circuits are available for dc and ac amplifiers, phase-shift amplifiers, frequency-selective amplifiers, filters, gates, flip-flops, switches, and relays.

Houston Instrument Corp., which has acquired the X-Y recorders, strip-chart recorders, and dc amplifiers of the Industrial Instrument Div. of Mandrel Industries, Inc.—in Houston, Tex. Under E. V. Hardway Jr., founder of the Beta Corp. (acquired by Robertshaw-Fulton Controls Co. in 1956), Houston Instrument will develop, manufacture, and market laboratory and industrial instruments for the petroleum and chemical fields. Jack Yeiser, formerly manager of the Mandrel division, heads the new firm's Laboratory Instrument Div.

Edal Industries, Inc., to manufacture a line of semiconductor components—in New Haven, Conn. This line will include a stabilized instrument rectifier, copper oxide and selenium diodes, selenium rectifiers, diode modulators, demodulators, phase comparators, and varistors.

General Controls, GmbH, a new European subsidiary of General Controls Co.—in Dusseldorf, Germany. The new unit will serve initially as an assembly, sales, and distribution center, later may do some manufacturing.

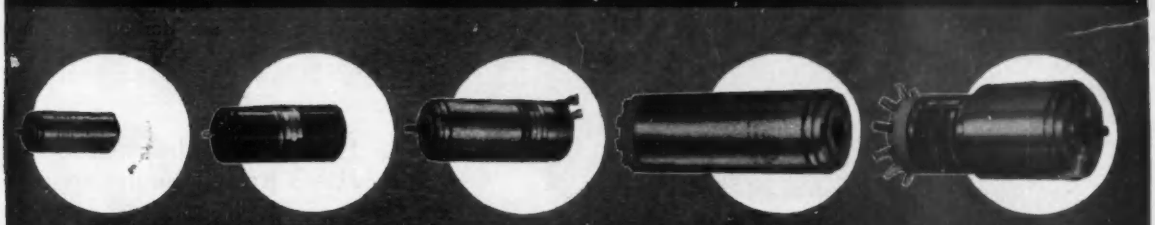
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SERVO MOTOR TACH GENERATORS

to your precise specification

Oster®

- Both Damping and Integrating types available with parameters to your requirement.
- Complete size range: 8, 10, 11, 15, 18. Can be designed with gear train.
- — 54° C to + 125° C ambient temperature range.
- Designed to MIL-E-5272.
- Assembled under closely controlled environmental conditions.



400 CPS SERVO MOTOR – TACHOMETER GENERATORS

Oster Type	Size	Length Inches	Wt. Oz.	Rotor Inertia gm cm²	MOTOR					GENERATOR				
					Rated Voltage Ø 1	Ø 2	No load speed RPM	Watts per phase @ Stall	Stall Torque OZ. IN.	Excit. Volt.	Output Volts per 1000 RPM	Lin.% to 3000 RPM	Null MV	Phase Shift @25°C
8MTG-6201-01	8	1.850	2.3	0.77	26	40/20	6,500	2.2	0.16	26	0.25	0.5	15	± 5°
*10MTG-6228-02	10	2.157	4.2	0.72	115	115/57.5	9,500	2.8	0.26	115	0.45	1.5	19	±10°
10MTG-6229-12	10	2.100	2.9	1.09	33/16.5	52/26	9,500	3.0	0.28	26	0.45	1.5	13	±10°
*10MTG-6229-03	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	18	0.3	1.5	12	±10°
10MTG-6229-15	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	26	0.3	1.5	12	±10°
*10MTG-6232-05	10	2.104	4.2	1.1	115	36/18	6,500	3.5	0.26	115	0.30	1.5	15	±10°
11MTG-6251-13	11	2.531	7.0	1.3	115	115/57.5	6,500	3.5	0.63	115	0.55	0.5	19	±10°
11MTG-6251-00	11	2.531	7.0	1.1	115	40/20	6,500	3.5	0.63	115	0.55	1.5	19	±10°
11MTG-6254-01	11	2.200	6.0	1.1	115	115/57.5	6,500	3.5	0.63	115	0.55	1.5	19	±10°
15MTG-6280-01	15	3.281	14.0	5.3	115	115/57.5	5,000	6.2	1.5	115	3.0	0.2	13	± 5°
†*15MTG-6276-03	15	3.875	15.0	4.4	115	57.5	8,500	5.8	0.70	115	2.75	0.2	13	± 0.5°
18MTG-6302-02	18	3.680	20.0	5.7	115	115/57.5	9,000	16.0	2.7	115	3.0	0.2	13	± 5°
18MTG-6302-04	18	3.680	20.0	5.7	115	115/57.5	4,800	9.2	2.4	115	3.0	0.2	13	± 5°

*These units designed for 85°C ambient but same characteristics can be designed for 125°C. †Additional 21.4 watts for heater, the values given are independent of ambient temperature.

Other products include servos, synchros, resolvers, motor-gear trains, AC drive motors, DC motors, servo mechanism assemblies, reference and tachometer generators, servo torque units, actuators and motor driven blower and fan assemblies.

John Oster MANUFACTURING CO.
Your Rotating Equipment Specialist
Avionic Division
Racine, Wisconsin

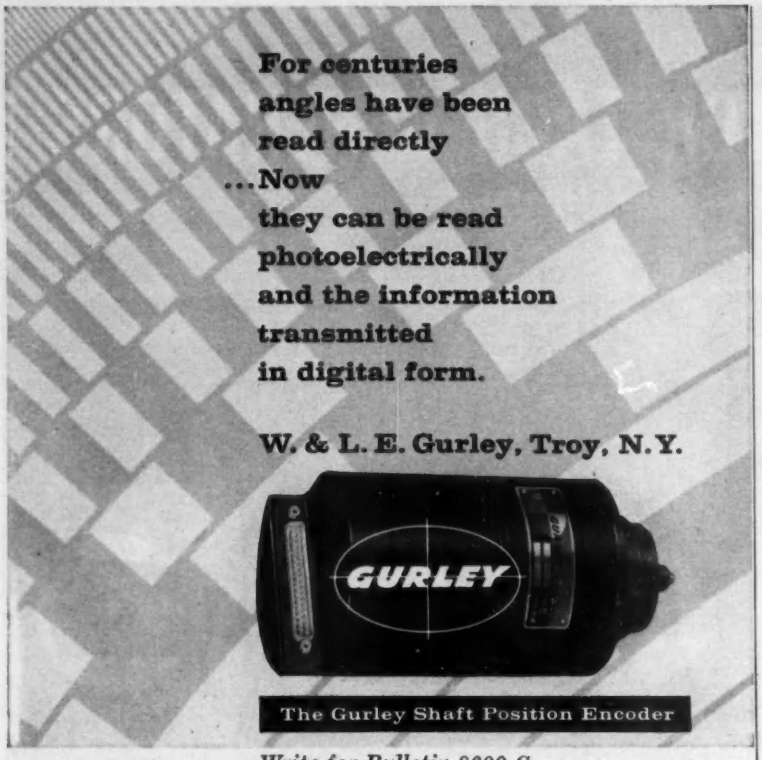
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- Unique design for wide range of machine applications — or modification for specific needs.

For help with *special* circuit control problems requiring design of new equipment, *call on our research and development specialists at the planning stage.*

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CIRCLE 126 ON READER-SERVICE CARD

WHAT'S NEW

IMPORTANT MOVES BY KEY PEOPLE

V-P's Jaeger and Shages Raised by Pratt & Whitney

Pratt & Whitney Co. has promoted Jacob J. Jaeger, formerly vice-president in charge of engineering, to executive vice-president, and Edward J. Shages, formerly vice-president and manager of the Cutting Tool & Gage Div., to vice-president in charge of all manufacturing operations. Jaeger has been with P&W since 1940, a vice-president since 1955. His new assignment gives him responsibility for all sales and manufacturing operations. Shages joined in 1929 as an apprentice, rose through company ranks.

Pfeffer of Struthers-Dunn Heads Relay Manufacturers

John L. Pfeffer has moved up from vice-president to president of the National Association of Relay Manufacturers. President of Struthers-Dunn, Inc., Pfeffer succeeds James V. Roughan, general manager of Consolidated Electronics Industries Corp., who has held the helm of the association for two years (CtE, April '57, p. 52).

Summers Imports Director of Engineering, Raises Henning

Jennings David has been named director of engineering, and Philip A. Henning chief engineer, of Summers Gyroscope Co. David comes from G. M. Giannini & Co., Inc., where since 1956 he was assistant division manager for the Gyroscope Div. Before that, he was with Cal Tech's Jet Propulsion Laboratory, and was a partner in a Pasadena, Calif., producer of fractional horsepower motors for the military. Henning advances from project manager for missile systems at Summers. Before joining the Santa Monica, Calif., company, he was with the Naval Ordnance Laboratory, Sylvania Electric, and Gilfillian Bros., Inc.

Other Important Moves

Magnetic Amplifiers, Inc., has appointed **Bernard J. O'Neill**, formerly chief engineer, vice-president in charge of engineering, a new post. His principal area of supervision will be new solid-state systems and products; at the same time, he will be in charge of all engineering and research activi-

HOW HIGH IS UP?





Some terms like "up," "long," "wide" or "high" are purely relative. "Reliability" is not a relative term—it is absolute!

The systems which regulate the flow of electricity, water, natural gas, petroleum and the other liquids and gasses which are so vital to our industrial and personal lives must be reliable—without compromise or qualification!

Since 1921 North Electric Company has designed, developed and manufactured thousands of such systems—systems which have established new standards of reliability.

North's unique capabilities in this field stem from 75 years of proven experience in the areas of communication and control, the two basic principles upon which a system complex is dependent.

For utilities, for industry, for defense—North engineered and built systems are functioning 24 hours a day, 365 days of the year—such reliability is inherent in every North Product.

North stands ready, *and able,* to give you specialized assistance in system design, development and manufacture.

Write, wire or phone

INDUSTRIAL DIVISION

NORTH ELECTRIC COMPANY

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CUT LAB EQUIPMENT COSTS IN HALF

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ELECTRONIC KITS

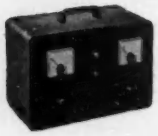


The Heathkit Model OP-1 Professional 5" DC Oscilloscope is an example of the top quality test instruments available from Heath at ½ the price you would expect to pay. This feature-packed kit sells complete for only $179.95.

Heathkits give you twice as much equipment for every dollar invested.



The Heathkit Model V-7A is the world's largest selling VTVM. Precision 1% resistors are used in the voltage divider circuit for high accuracy and an etched circuit board simplifies assembly and cuts construction time in half. Price of this outstanding kit is only $25.95.

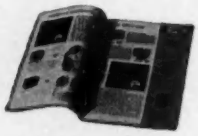


The Heathkit Model PS-4 Variable Voltage Regulated Power Supply Kit is another outstanding example of Heath Company engineering ingenuity. Truly professional in performance as well as appearance yet it costs only $54.95.

Stretch your test equipment budget by using HEATHKIT instruments in your laboratory or on your production line. Get high quality equipment without paying the usual premium price by letting engineers or technicians assemble Heathkits between rush periods. Comprehensive step-by-step instructions insure minimum construction time. You'll get more equipment for the same investment and be able to fill any requirement by choosing from more than 100 different electronic kits by Heath. These are the most popular "do-it-yourself" kits in the world, so why not investigate their possibilities in your business. Send today for the free Heathkit catalog!

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CIRCLE 128 ON READER-SERVICE CARD

WHAT'S NEW

ties of the company. He joined Magnetic Amplifiers in 1951.

Writer-educator **James R. Irving** has been named executive secretary of the Laboratory Equipment Section of the Scientific Apparatus Makers Association. Succeeding him as director of public information of SAMA is **Nicholas G. Geannopulos,** whose experience in public relations spans the fields of science, medicine, and engineering.

David R. Miller, formerly manager of the Computer Systems Div. of Colorado Research Corp. of Broomfield, Colo., has been appointed director of marketing by that company. The two-and-a-half-year-old Carrier Corp. subsidiary now has ready for marketing missile tracking and communications equipment, flight data processing equipment, precision shaft-angle encoding systems, and analog computers. Miller's successor in the Computer Systems Div. is Mark Harris II, formerly assistant manager of the division.

George J. Brown has advanced from project engineer to chief engineer of Statham Instruments, Inc. He came to Statham a year ago from Sandberg-Serrell Corp., where, as vice-president, he concentrated on missile systems.

A former chief of electronics engineering and senior electrical engineer for Creole Petroleum Corp., Venezuelan subsidiary of Standard Oil of New Jersey, has joined Litton Industries in the Advanced Systems Engineering Dept. of the Electronic Equipments Div. He is **B. William Miller,** most recently with the Autonetics Div. of North American Aviation as executive advisor, and before that with Creole.

Walter J. Albersheim, formerly with Bell Telephone Laboratories, has joined Spencer-Kennedy Laboratories, Inc., Boston electronics company, as chief engineer. He had been with Bell Labs since 1941.

The new director of semiconductor research for the Research Div. of Raytheon Mfg. Co. is **W. Crawford Dunlap,** formerly supervisor of solid-state research at the Bendix Aviation research laboratory in Detroit. Before that, Dunlap was with the GE research laboratory in Schenectady, N. Y. He is a fellow of the American Physical Society and a senior member of the IRE.

Telectro Industries Corp. of Long Island City, N. Y., has appointed **George Brown Sr.** chief engineer. He most recently was systems engineer of this magnetic tape equipment maker, before that was with Philips Radio.

Select the range for your requirements ... with these *ElectroniK* instruments

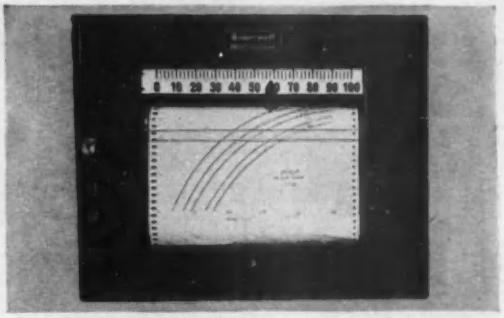
You get the advantages of *ElectroniK* accuracy and dependability in these special instruments . . . plus design ruggedness proved by around-the-clock service in industrial applications. They measure and record or indicate . . . quickly, precisely, conveniently. You'll find them particularly valuable in laboratory or test cell work where clear-cut evaluation and high resolution are needed.

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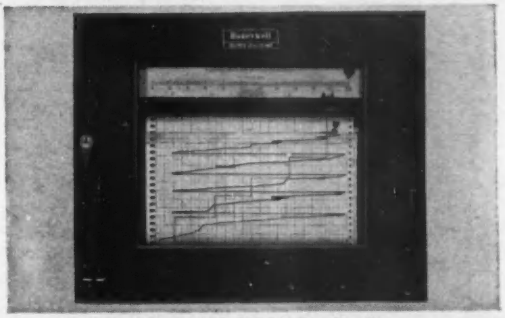
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

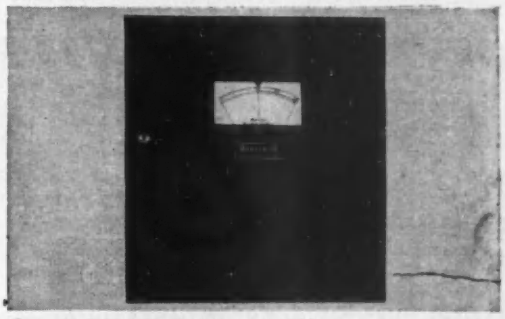
First in Controls



ElectroniK **FUNCTION PLOTTER—Automatically and continuously plots a curve which shows the relationship of one variable to another. Typical uses: speed versus torque, stress versus strain, plate voltage versus plate current, and many other variable relationships. *Write for Instrumentation Data Sheet 10.0-5b.***



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BULLETINS AND CATALOGS

(300) OVERHEAT DETECTION. Walter Kidde & Co. Bulletin, 8 pp. Covers the operation and application of a continuous, resetting, thermistor-type overheat detector. A generalized temperature-resistance curve illustrates the detection of fire and overheat conditions by use of predetermined signal settings.

(301) PRECISION VALVES. Hoke, Inc. Catalog No. II A 1, 12 pp. Tables list specifications and sizes for different types of manually-operated precision valves in sizes from ⅛ to ½ in. Ten flow curves cover water and air ratings.

(302) SOUND MEASUREMENT. H. H. Scott, Inc. Booklet SIP. Illustrated catalog sheet gives full details on the company's sound-level meter, sound analyzer, and other instruments.

(303) THERMOMETERS. Rochester Mfg. Co. Catalog, 12 pp. Offers detailed descriptions and specifications on a complete line of industrial thermometers, including three new models. Explains reasons for hermetic sealing, external recalibration, and double damping.

(304) ACID ANALYZER. Phoenix Precision Instrument Co., Inc. Bulletin K-5000, 12 pp. Deals with a new automatic recording amino acid analyzer. Includes a semischematic diagram of the flow system and typical chromatographic patterns obtained on the instrument's strip-chart recorder.

(305) LINEAR POTS. Helipot Div. of Beckman Instruments, Inc. Data Sheet 1357, 4 pp. Tells the complete story of the 1¾-in. Helipot Series 5500 single-turn precision potentiometer. Lists environmental characteristics, coil characteristics, and complete preliminary specifications.

(306) CENTRALIZED CONTROL. Panellit, Inc. Bulletin 106, 16 pp. Illustrates and describes the design approach, materials and facilities used in manufacturing a variety of centralized control and data-presentation systems.

(307) RECORDER/REPRODUCER. Mincom Div. of Minnesota Mining & Mfg. Co. Bulletin, 4 pp. Reviews specifications, performance characteristics, and design features of the new Mincom seven-track video-band magnetic recorder/reproducer. Includes photos of oscilloscope traces, calibrated in microsec per cm.

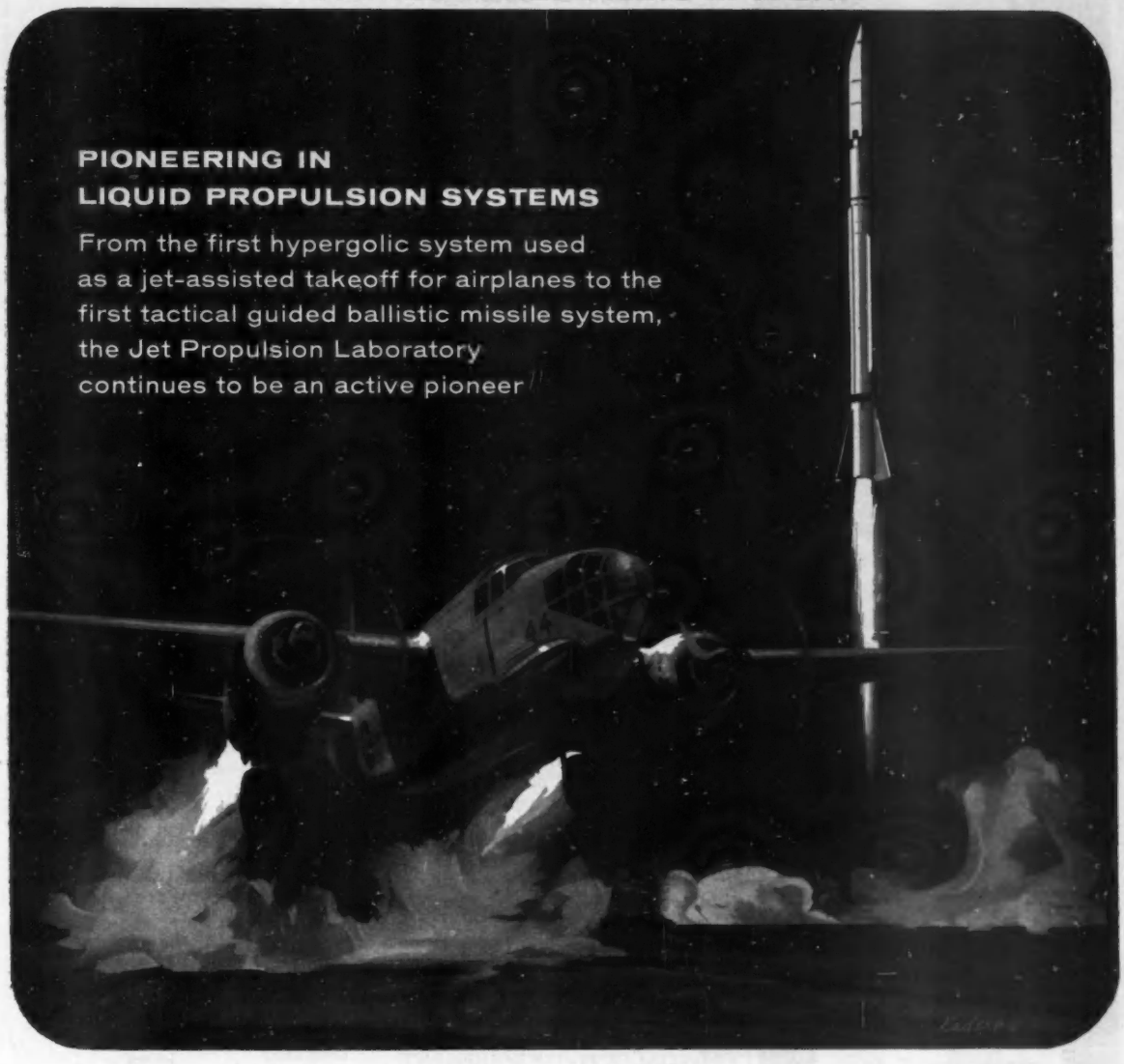
(308) ERROR BRIDGE. Theta Instrument Corp. Technical bulletin, 4 pp. Photo and schematic diagram illustrate a new system error bridge. Last page covers input simulator applications.

(309) X-Y RECORDER. Houston Instrument Corp. Bulletin 717-3, 4 pp. A detailed description of the HR-92 null-seeking type x-y plotter for drawing curves in cartesian coordinates on regular 8½ by 11 paper. Lists specifications.

(310) UNIVAC AT WORK. Remington Rand Div. of Sperry Rand Corp. Bulletin U1566, 4 pp. Question and answer type of presentation tells how the New York Transit Authority uses a Univac 120 electronic computer for a variety of data-processing applications.

(311) PNEUMATIC VALVES. Ross

NOTABLE ACHIEVEMENTS AT JPL...



Months before Pearl Harbor, JPL had tested America's first liquid rocket engines using spontaneously igniting propellants. By April 1942, a simple nitric acid-aniline propulsion system was designed into and successfully tested in an A-20-A Bomber for a jet-assisted takeoff. For high-altitude atmosphere research purposes, JPL then used the hypergolic liquid rocket system in the WAC CORPORAL. Placed as a second stage on a V-2 rocket, this became the BUMPER WAC rocket that established a World's altitude record of 242 miles in February 1949.

At the request of U.S. Army Ordnance, the Jet Propulsion Laboratory now began to develop a long-range guided ballistic missile system, incorporating the proven, smooth-burning light-weight acid-aniline system. These achievements sparked the development of a whole series of rocket vehicles. In 1954, the Army accepted the JPL developed CORPORAL, which became America's first tactical guided ballistic missile system; its accuracy exceeded design requirements.

Under the direction of the National Aeronautics and Space Administration, the experienced Jet Propulsion Laboratory research and development team is now working on storable, high-performance hypergolic liquid propulsion systems with which space vehicles may soon orbit the moon and planets.

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Bulletins & Catalogs

Operating Valve Co. Condensed catalog. Installation and maintenance information as well as dimensional and parts data cover more than 40 popular types of pneumatic valves. Models are grouped according to mode of operation—air, cam, solenoid, and manual.

(312) MAGNETIC FLOWMETERS. Fischer & Porter Co. Catalog 10D1416, 6 pp. Discusses the operation and performance of the Model 10D1416 magnetic flowmeter. Wiring diagram and cutaway view of the unit amplify the text.

(313) RECORD ELAPSED TIME. Sphinx-American Corp. Bulletin, 4 pp. Covers three new aircraft clocks that serve as split-second timers, elapsed-time recorders, and accurate timepieces. Following each description is a brief review of the models available, dial types, and markings.

(314) JET TEMPERATURES. B & H Instrument Co. Brochure, 4 pp. Introduces the BH-183 AutoTemp, a new temperature indicator designed specifically for use on jet engines. Schematic diagram illustrates its basic components; photos show two views of its internal assembly.

(315) FUEL CONTROL. Systems Div. of Consolidated Electrodynamics Corp. Bulletin 3016, 6 pp. Sixth in a series on systems application, this bulletin deals with the operation of a control system for testing high-performance mechanical components in missile fuel systems.

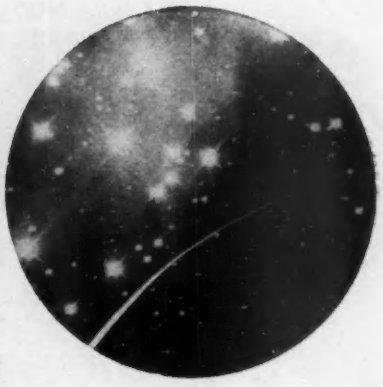
(316) PLASTIC PIPING. Chemtrol. Handbook C-159, 16 pp. Describes the technology of plastic piping systems—types of materials used, installation and coupling methods, standards for plastic pipe, plastic valves, and a table showing the effects of 280 chemicals on five different types of plastic.

(317) TEST CHAMBERS. Statham Development Corp. Bulletin, 4 pp. Features a full page of specifications on a complete line of temperature test chambers with ranges as wide as minus 70 to plus 400 deg C. Line drawing illustrates the operating principle.

(318) CONDUCTIVITY EQUIPMENT. Industrial Instruments, Inc. Catalog 23, 32 pp. Leads off with a brief discussion of the technique of measuring electrolytic conductivity, then goes into detailed descriptions of the various types of equipment used. Covers bridges, indicators, controllers, recorders, alarms, selector switches, conductivity cells, etc.

(319) OPTICAL RECORDER. Sanborn Co. Specification sheet, 2 pp. Contains preliminary specifications on the Model 670 X-Y recorder, a unit that provides optical recording speeds greater than 2,500 in. per sec. Schematic drawing shows how a mirror-galvanometer system controls the recording light beams; block diagram illustrates basic circuit elements.

(320) LABORATORY TESTING. Freed Transformer Co. Catalog No. 558. Gives complete specifications on a full line of precision laboratory test equipment. Instruments include low-frequency Q indicators, comparison and limit bridges, incremental inductance bridges, universal bridges, voltmeters, and distortion meters.



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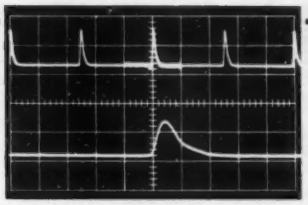
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TYPE 555



SWEEP DELAY
Simultaneous display of pulse chain (upper beam) and third pulse on expanded delayed sweep (lower beam). Portion of original display that appears on faster delayed sweep is identified by trace brightening.



Two electron beams, each with its own X and Y deflection plates, help make possible a highly versatile dual-beam oscilloscope. Either of the two time-base generators in the Type 555 can deflect either beam for dual and single displays, and either can deflect both beams for a dual display on the same time base.

With one time-base generator functioning as a delay generator, the start of any sweep generated by the other can be held off for a selected time interval with a high degree of accuracy. Both the original display and the delayed display can be observed at the same time. The "triggered" feature can be used to obtain a jitter-free display of signals with inherent jitter.

Signal-handling versatility is provided by nine available types of plug-in preamplifiers, any combination of which can be used in the two fast-rise vertical channels. In addition to the many application areas opened with Tektronix plug-in preamplifiers, a three-channel or four-channel display is available through use of the time-sharing characteristics of Type C-A Dual-Trace Units in one or both channels.

Please call your Tektronix Field Engineer or Representative for complete specifications.

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INDEPENDENT ELECTRON BEAMS
Separate vertical and horizontal deflection of both beams.

FAST-RISE MAIN VERTICAL AMPLIFIERS
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Risetimes—12 mμsec with Type K Units.
All Tektronix Plug-In Preamplifiers can be used in both vertical channels for signal-handling versatility.

WIDE-RANGE TIME-BASE GENERATORS
Either time-base generator can be used to deflect either or both beams.
Sweep ranges—0.1 μsec/cm to 12 sec/cm. 5 x magnifiers increase calibrated sweep rates to 0.02 μsec/cm.

SWEEP DELAY—Two modes of operation.
Triggered—Delayed sweep started by signal under observation.
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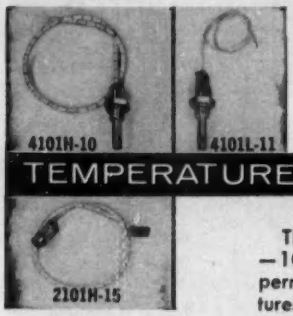
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The surface transducer (2101H-15) is for materials of limited area and thickness, and has great mounting versatility.

Both air and surface types are available in two calibration ranges: —100 F to +500 F, —100 F to +1200 F.

Other Specifications:

Calibration accuracy: 0.1-1.0%, depending on temperature range

Repeatability and hysteresis: within calibration accuracy

Resistance at 32 F: 100 ±5 ohms

Nominal temperature-resistance coefficient: 0.0018/°C

Output: 0-5 vdc, when Arnoux 100-ohm TME is used.

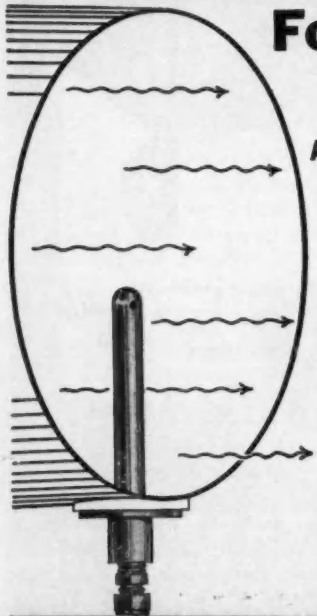
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NEW BOOKS

Another Text on SDCS

SAMPLED-DATA CONTROL SYSTEMS. *Eliahu I. Jury, University of California, Berkeley.* 453 pp. *Published by John Wiley & Sons, Inc., New York,* 1958. $16.

Professor Jury's book becomes the second to appear in recent months dealing exclusively with the analysis and synthesis of sampled-data control systems (SDCS), thereby demonstrating a growing interest in this area of control engineering. Anyone familiar with the literature of SDCS will certainly be aware of Professor Jury's numerous contributions to the field. His development of modified z-transform techniques removed, at one stroke, the major objection to z-transform methods; namely, lack of information about system response between sampling instants. Almost single-handedly he simplified and systematized the application of root-locus techniques to SDCS. He has also been one of the leading exponents of time-domain synthesis of compensation networks. How well has Professor Jury integrated these topics into his overall treatment of SDCS?

Chapters 1 and 2 of this book introduce the reader to the z-transform and modified z-transform methods. They are devoted almost exclusively to SDCS applications, such as the development of sampled-data transfer functions for various system configurations, the analysis of multiple-sampler systems, tests for system stability, and the analysis of systems with transportation lags. Methods for obtaining the inverse transforms are also demonstrated, including a very interesting method for obtaining inverse Laplace transforms from the inverse modified z-transform. Analysis in the z plane is continued in Chapter 3, which discusses the root-locus method and its applications. Phase-angle loci are also used to obtain correlation between pole-zero configurations and system transient response. Of special interest is the derivation of equations for transient overshoot and peak time for systems that can be approximated by a single dominant pair of complex poles, a situation that occurs frequently enough to make these relations worthwhile. In Chapter 4, frequency response methods of analysis are presented, supplementing z-transform methods with the more familiar Bode and Nyquist diagrams.

Chapter 5 discusses control system synthesis using discrete compensation,

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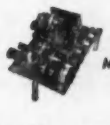
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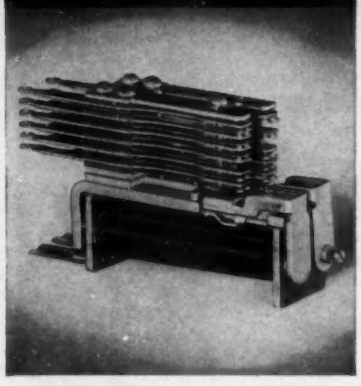
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NEW BOOKS

while Chapter 6 deals with compensation using continuous networks. In Chapter 7, various techniques are presented for obtaining the desired compensation network transfer function, with most of the emphasis on the physical realization of discrete compensators.

Chapter 8 is essentially independent of the preceding chapters; it discusses the uses of the z-transform and modified z-transform in numerical analysis. About 70 percent of the chapter is devoted to the approximate analysis of continuous systems; the remaining 30 percent covers the operational solution of linear difference equations having either constant or periodic coefficients. Finally, in Chapter 9 the author relaxes the key assumption that is fundamental to all z-transform analysis: that sampling time is small compared to the dominant time constants of the system. In this chapter he considers systems in which the sampler has finite pulse width. Using the method of p-transforms (developed by G. Farmanfarma, one of Professor Jury's graduate students), exact analysis of both open-loop and closed-loop pulsed feedback systems are presented. The author examines in detail various limiting cases of the p-transform and discusses the relations between Laplace transforms, z-transforms, and p-transforms.

In addition to these nine chapters, the book contains some very extensive tables of transforms (regrettably not listed in the table of contents), a comprehensive bibliography, and many problems of varying degrees of difficulty. All told, Professor Jury has covered a wide range of topics in this book.

However, the book's greatest asset —its wealth of information—is marred by inadequate editing. The writing is "disconnected" with no underlying unity to the chapters. While the material is certainly there, it may take some digging to find it.

There is also one glaring omission in Chapter 8. Professor Jury's explanation of the method of Boxer and Thaler (the z-form method) was necessarily brief, since it was not the major topic of interest in the chapter; but his explanation, while it did include tables of z-forms, failed to tell the reader how to use them. This is equivalent to teaching an engineer how to read a table of Laplace transforms without teaching him how to solve problems using this technique.

—Leslie R. Axelrod

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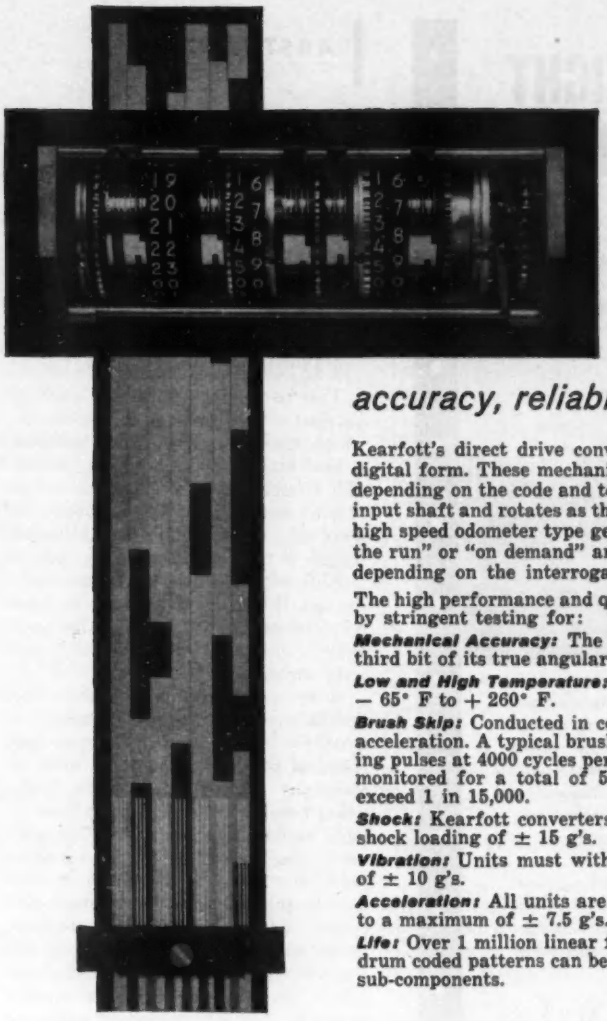
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Code (1)	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	C.B. (Gray)
No. of Drums	1	1	2	3	3	4	5
Range	0 to 84 in 348.5° of arc. 11.5° dead spot coded O	−19 to 0 to + 19	0 to 359	(+) 0 to (+) 999 (−) 999 to (−) 0	0 to 359.9	0 to 359.9	0-32,768 (2^{15})
Bits per Revolution	85	39	40	20	40	40	16
Revolutions for Total Range	1	1	9	100	90	90	2,048
Volts D.C.	23	12	23	23	23	23	10.5
Current (ma.)	20	20	20	20	20	20	20
Inertia (gm. cm.²) (2)	158	48	104	28	158	100	20
Unit Diameter (in.)	2⅛	1¾	1⅝	1⅛	1⅝	1.875	1⅛
Unit Length (in.)	31/32	1⅛	1-43/64	1⅝	2⅛	2.8125	3
Life (3)	10^6 revolutions or 10^3 hours						
Static Torque (in.-oz.) (4)	0.5	0.1	1.0	.5	1.0	1.0	2 (break) 1 (running)
Weight (oz.)	5	3.5	5.75	4	7.75	6.5	5
Maximum Speed (RPM)	1100	250	300	400	300	700	600
Dielectric (Volts DC)	500	500	500	500	500	500	500

(1) B.D. (Binary Decimal), C.B. (Cyclic Binary).
(2) Inertia measured at maximum trip.
(3) Under recommended conditions.
(4) At room temperature.

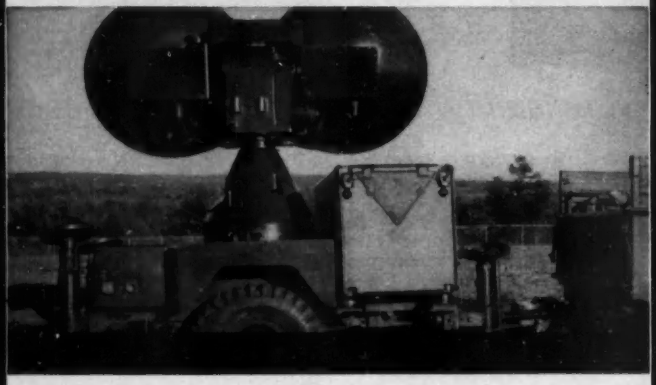
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ABSTRACTS

Positioning Heavy Loads

From "The Design of Systems for Automatic Control of the Position of Massive Objects" by A. Tustin, J. T. Allanson, J. M. Layton, and R. J. Jadeways. Paper 62651N, Proceedings of the Institution of Electrical Engineers, Vol. 105, Part C, Supplement No. 1, 1958.

This paper deals with that particular class of feedback control systems in which the power required to position a load is far beyond the capabilities of a vacuum-tube amplifier. Kilowatts or even hundreds of kilowatts may be involved, in which case additional stages of magnetic or rotary power amplification are needed. Concentrating on this narrow class of systems helps to establish definite design procedures that will minimize trial and error techniques.

A review of the requirements for satisfactory performance indicates a need for certain limits. Torque and speed of the load must be limited; so must the settling time of the load, when coming into alignment from a large initial misalignment. Excessive error, due to disturbances superimposed on the error signal, must not lead to saturation of the control elements. Motion of the load at low speeds should be smooth in spite of the tendency of "stiction" to produce jerks. Performance must be maintained in spite of component aging or replacement. In analyzing such a system, a useful approach is to express each requirement as a constraint on the form of the log-gain versus log-frequency characteristic.

The usual procedure of taking the elements of a basic control loop and designing a stabilizing network fails to satisfy the system requirements. The time constants associated with the power amplifying elements depend on the power and dominate the design. Certain minimal assumptions can be made about the characteristics of a modifying network or phase advancer. Beyond the limits set by these assumptions, system specifications are met by suitable choice and arrangement of the additional amplifier stages.

Introducing the relationship between power amplification and the associated time constants makes it possible to express the condition for adequate damping in terms of required amplification and accuracy, together with characteristic functions for

various classes of machine-amplifier elements. These simple functions express the contribution made by each element toward using up the limited amount of phase-lag allowable. Such functions have been termed "phase-utilization functions" and, for given classes of dynamically similar elements, can be calculated once and for all. Thus they provide a basis for comparing different forms of power amplifiers and for designing the most satisfactory elements.

In the next section of this paper, the authors discuss in detail the design of the motor and generator required to provide the statistically defined movements of the load. This leads to a definition of the amplification required and establishes a basis for adequately rating each element. It also provides a prior estimate of the supplementary phase angle associated with the motor armature.

Section 3 covers the selection of machine-amplifier elements and develops the concept of phase utilization, and makes use of the fact that the time constants are related to the power amplification.

The fourth section shows how modifying networks, for insertion in the vacuum tube stages, may be selected so as not to exceed any of the limitations established earlier.

Section 5 discusses the use of feedback on machines. Here the authors show how the apparent benefits of some types of feedback may be offset by reduction of the power amplification. This leads to a discussion of feedback elements, such as transformers which introduce a derivative term.

A concluding section briefly reviews a possible design procedure for a system that will conform to the desired time constants. This section also covers performance limitations and suggests some possible improvements.

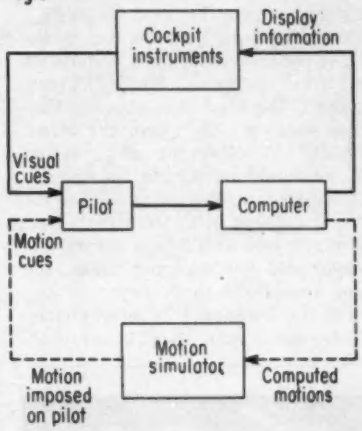
Motion Adds Realism

From "Use of Flight Simulators for Pilot Control Problems" by G. A. Rathert Jr., B. Y. Creer, and J. G. Douvillier Jr., all of the Ames Research Center, Moffett Field, Calif. NASA Memo 3-6-59A, February 1959, obtainable from the National Aeronautics & Space Administration, Washington, D. C.

Flight simulators for training purposes become more popular as actual flight experience becomes more complex and expensive. Logically, training simulators may be divided into two classes: procedure trainers that familiarize the student with operating procedures, and proficiency trainers designed to give the pilot realistic practice in operating flight controls and observing airplane response. This paper discusses the second type and investigates flight characteristics that make the use of motion stimuli either mandatory or at least desirable.

Figure 1 illustrates a typical pilot-operated simulator. The solid-line

Fig.1



loop shows the basic elements of a fixed simulator and the broken-line loop indicates the added refinement of motion simulation.

Physically, the techniques and equipment used to furnish the motion cues may differ, but the principle is the same in each case; i.e. the pilot is shown the instruments as they would appear in actual flight, and is also placed under motion conditions that more or less duplicate those of the same flight.

At the Ames Research Center, comparisons have been made between a pilot's capabilities in actual flight and those exhibited on fixed and limited motion simulators. Although more complex simulators have yet to be tested, results so far prove that the need for motion cues depends entirely on the type of task given to the pilot.

Piloting tasks compared at Ames include: landing approach, longitudinal dynamics, longitudinal control, lateral dynamics, instrument presentation, and simulation of particular airplanes. In each case motion inputs were either unnecessary, helpful, or mandatory.

In the landing approach simulation, the most critical piece of information required by the pilot is the rate of sink. This can be furnished by visual

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ABSTRACTS

information alone, and tests showed that while motion stimulus was desirable, it was not actually necessary. In choosing an approach speed on a fixed simulator, most pilots were within 5 knots of the speed chosen in actual flight.

To study the problem of longitudinal dynamics, a comparison was made between flight tests performed by the Cornell Aeronautical Laboratory and tests made on a fixed simulator at Ames. In both tests, pilots rated the various combinations of short-period frequency and damping as good, acceptable, or poor. Figure 2 (page 202) shows agreement between the studies in the region of moderate frequencies and good damping. Above 0.6 cps, however, the fixed simulator becomes much easier to "fly" than the actual aircraft. Whether or not motion stimuli would be needed for longitudinal dynamics, then, depends on the type of airplane being simulated. Certainly, for one with a high natural frequency and low damping factor, the fixed simulator is inadequate.

For the longitudinal control characteristic pilots were asked to rate first-



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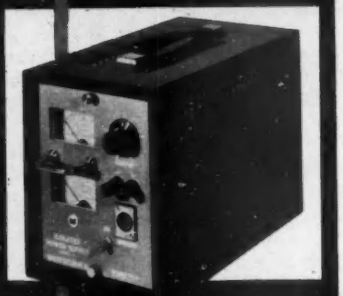
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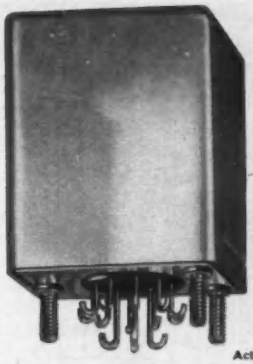
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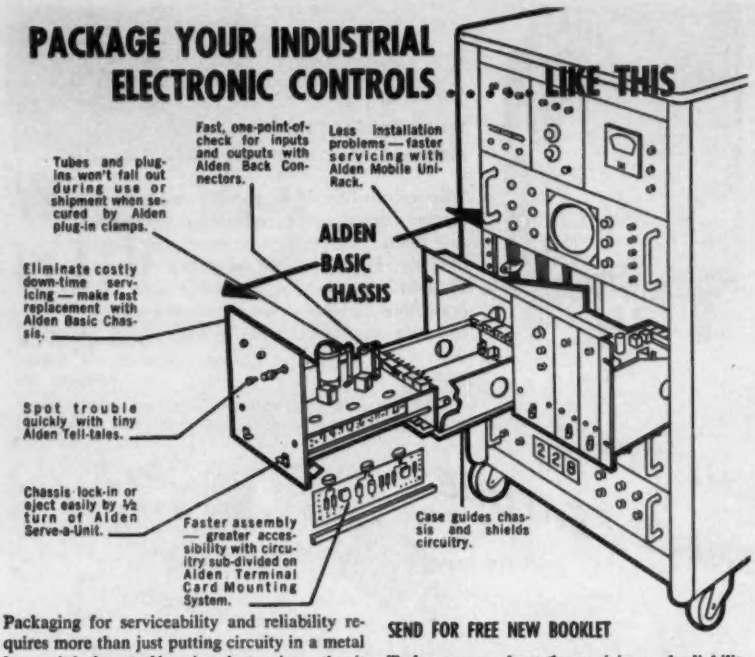
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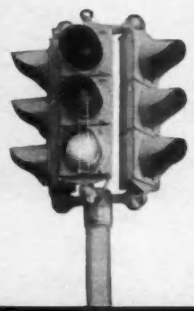
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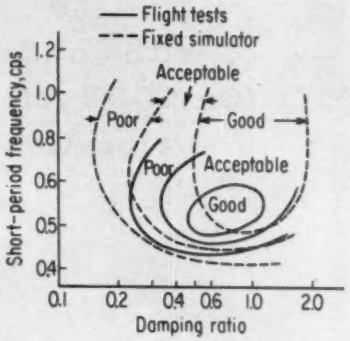
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ABSTRACTS

Fig.2

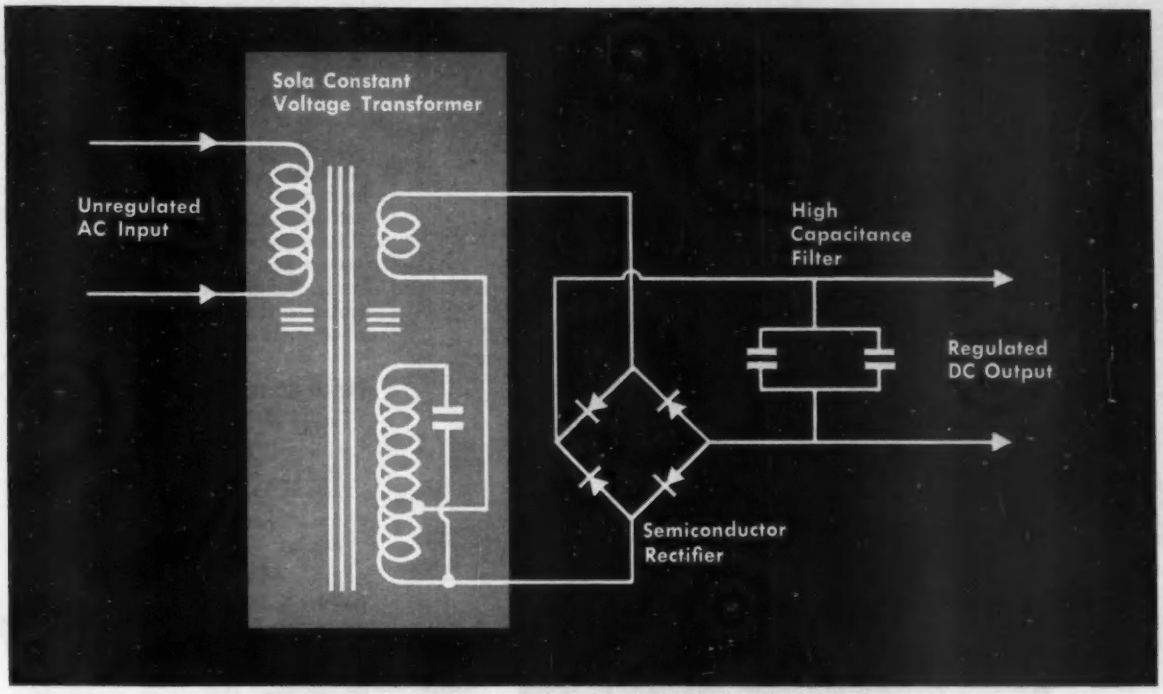


order time constants versus stick forces as either "too sluggish", "too sensitive", or "best available." Again, ratings were made both on a fixed simulator and an actual airplane. Aside from individual differences of opinion, results showed that for rapidly responding controls at low stick force, pilot-induced oscillation can occur in actual flight but cannot be produced on a fixed simulator. However, unless this area of high sensitivity is of direct concern, motion feedback is not mandatory.

Actual flight tests as well as tests on both fixed and moving simulators were made to study the problem of lateral dynamics. In this case, results showed that for high rolling accelerations the fixed simulator was entirely unrealistic. Also at low rolling rates the moving simulator was easier to "fly" because of the motion cues it supplied.

The matter of instrument presentation is still quite controversial. One example is the method of presenting fire-control information. Some advocate the inside-out method, in which the pilot sees a fixed circle in the center of the scope, an artificial horizon, and the moving target. Others favor the outside-in method, in which the pilot sees a fixed target in the center of the scope, and his own plane moving in relation to the fixed target. Tests, again in actual flight and in moving and fixed simulators, were made to determine the extent to which motion simuli could improve proficiency. These tests showed that the inside-out presentation resulted in better performance in actual flight and in the moving simulator, but about equal performance in the fixed simulator. However, the correlation between actual flight and moving simulator results was far from ideal, and much work remains to be done.

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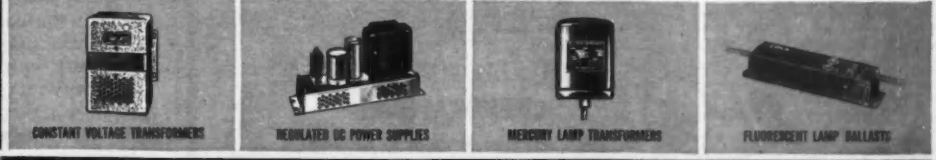
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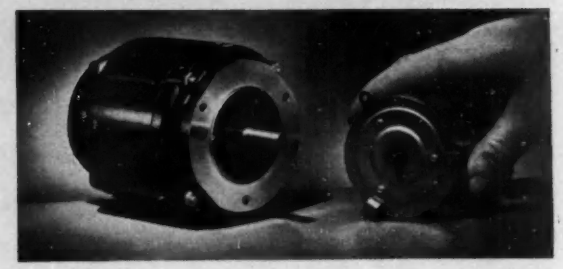


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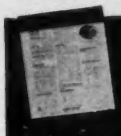
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ABSTRACTS

tion of a particular airplane has been limited largely to exotic-type craft such as the X-15, X-18, and various satellite and reentry configurations. Tests indicate, however, that the more tasks a pilot must perform simultaneously, the greater is his need for motion cues that permit certain responses to be made instinctively.

Near-Ideal Strain Gages

From "Semiconductors in Strain Gauges" by W. P. Mason of the Bell Telephone Laboratories. Article published in the Bell Laboratories Record, Vol. 37, No. 1, January 1959.

Devices for converting a mechanical motion into an electrical signal are numerous; their applications, even more numerous. This article concerns one particular category of such devices, viz., those used as gages for measuring quantities such as tension, compression, acceleration, shear forces, and torque.

The most important materials currently used in these electromechanical transducers are the piezoelectric type, in which motion produces a voltage, and the piezoresistive type, in which motion produces a change in resistance. Magnetostrictive materials, in which velocity produces a voltage, are of little interest here.

Ideally, transducers of this type should possess the following characteristics: high sensitivity to small forces; good response to both static and high frequency forces; operation over a wide range of temperature and humidity; and long-term stability. In addition they ought to be easy to fabricate and light enough so as not to load the object being measured.

While piezoelectrics perform well at high frequencies, leakage currents mask their response to static and low-frequency forces. They also lose their effectiveness at high temperatures and high humidities. Some newer types offer better temperature and humidity characteristics, but tend to change with time and may even depolarize under high stress.

With the piezoresistive materials, such as the constantan, platinum, or nickel wire often used in strain gages, sensitivity represents a limiting factor. Sensitivity of a strain gage, for example, is described by its gage factor, dR/RS, where dR represents the change in resistance with strain S. To illustrate this, if a constantan

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wire has an unstrained resistance, R, of 50 ohms, which increases by 0.01 ohm at a strain, S, of 0.0001 in. per in., its gage factor is 0.01/(50 x 0.0001) or 2. Platinum-wire yields are somewhat higher, while nickel wires produce values as high as 20.

But compare this with some of the values obtained with semiconductor strain gages. Gages using germanium, for example, have factors as high as 150, and silicon permits values up to 175. Figure 1 shows a simplified drawing of a germanium strain gage

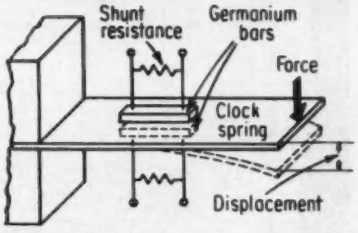


Fig. 1

used for measuring displacement. The only factor limiting sensitivity of this particular gage was the normal vibration of the building in which it was used. To eliminate this effect, the shunt resistance was added; but even then its gage factor was still 14 times higher than that of an ordinary wire gage. In general, germanium, silicon, and other semiconductors can produce gage factors about two orders of magnitude higher than wire gages.

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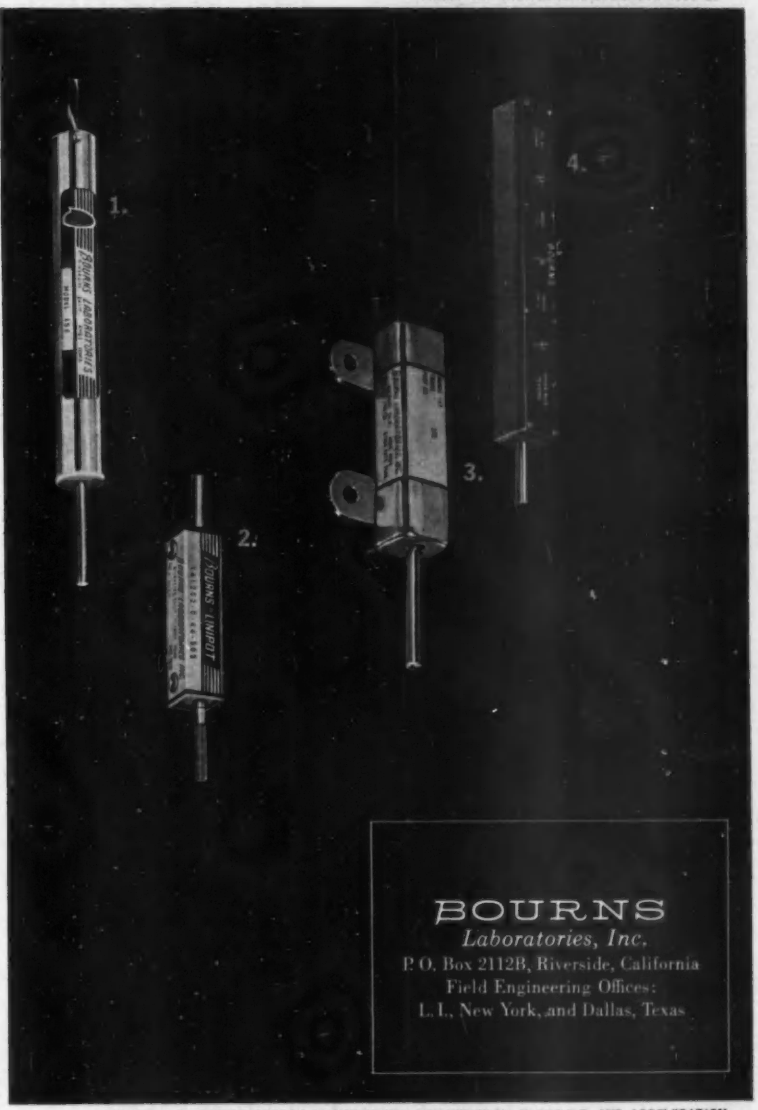
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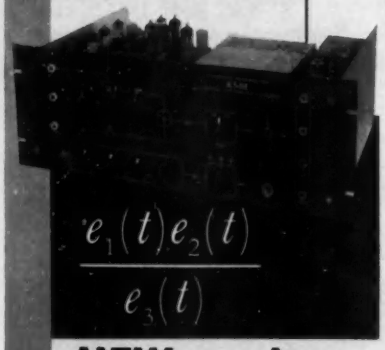


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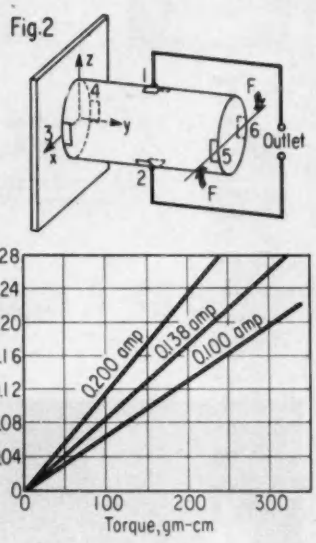
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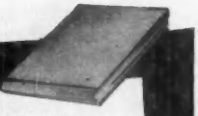
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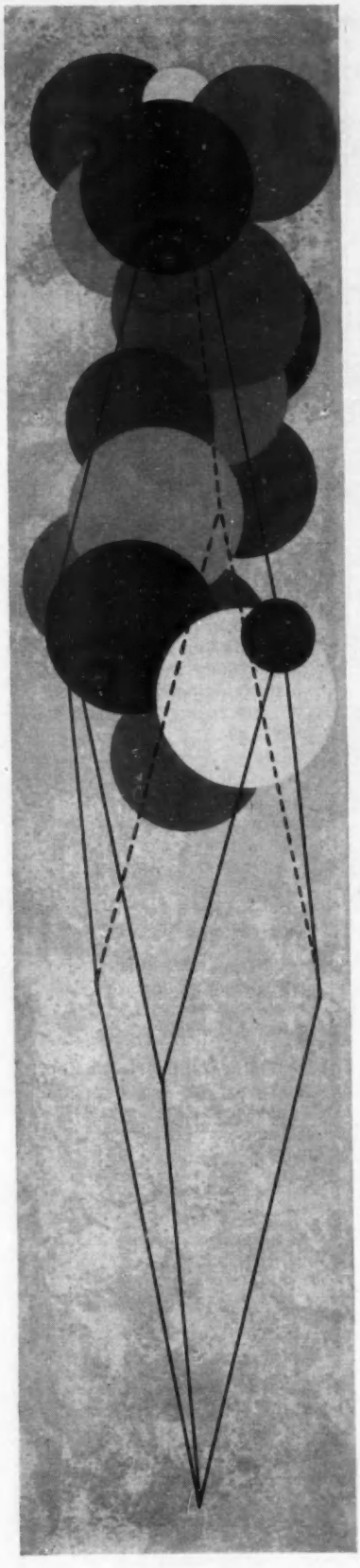
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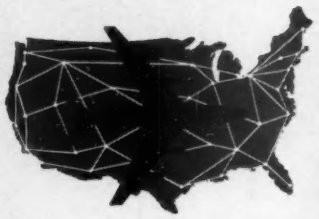
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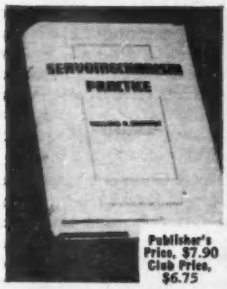
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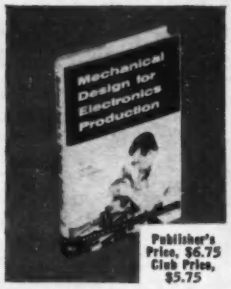
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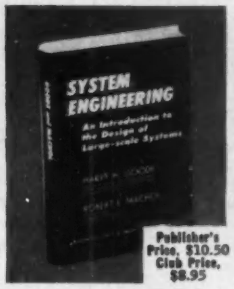
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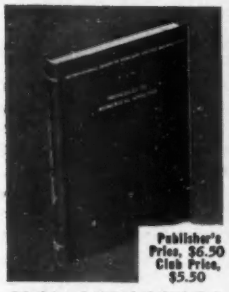
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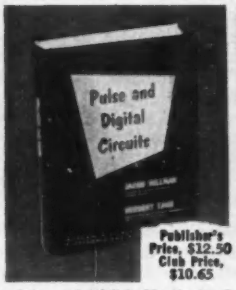
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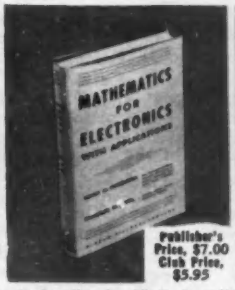
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First-Hand Report on Control Inside Russia, November 1958, 16 pp. A team of 14 U. S. control engineers representing the American Automatic Control Council reports on the status of automatic control in Russia. Each expert gives impressions of progress in his field of interest based on visits to Russian user plants and research facilities. 40 cents.

Electronic Process Control Systems, November 1958, 16 pp. A staff report on the hottest area in materials processing control. Besides giving complete data on the six commercially available electronic process control systems (four of them were first announced at the 1958 ISA show), the article discusses the common denominators of all such systems and points out why user, consultant, and maker are interested in electronics. 40 cents.

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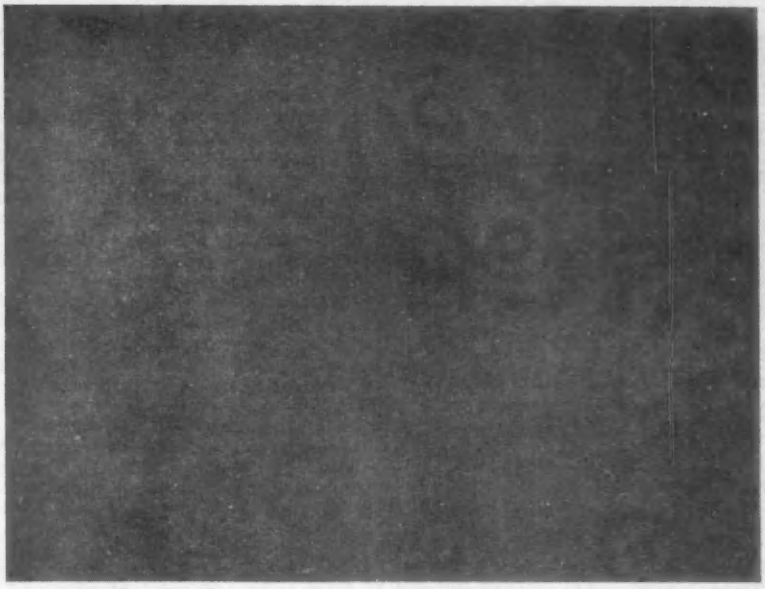
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What the Control Engineer Should Know About Reliability, April 1958, 8 pp. Not intended as a comprehensive treatise, but rather as a guide to aim the control engineer in the right direction, this staff-written article discusses the new concept of systems effectiveness, and briefly covers techniques for measuring reliability, predicting reliability, improving reliability, and costing reliability. Up to date refer-

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Transistor and Thyratron Power Amplifiers, 28 pp. These three articles—one on transistors and two on thyratrons—were prompted by the increasing control application of transistors as low-power amplifiers and thyratrons as high-power amplifiers. In each case the emphasis is on practical application, circuit design, system stabilization, etc. 50 cents.

Continued on Page 216

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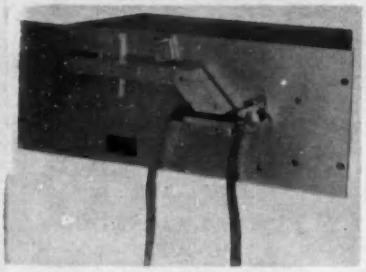
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Static Switching Devices—New Tools for Industrial Control, May 1957, 28 pp. An independent consultant analyzes the complete field of industrial static-switching systems. Starting off with a review of basic switching logic, he covers circuit characteristics of the fundamental devices, commercially-available systems, actual applications, etc. 50 cents.

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Committee on Control, Guidance, & Navigation is one of 13 new research advisory committees named to aid the National Aeronautics & Space Administration. Chairman of the new control advisory group: Dr. Louis N. Ridenour, Lockheed Missile Systems Div.

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International Atomic Exposition and Nuclear Congress, Public Auditorium, Cleveland April 5-10

Instrument Society of America, Second National Symposium on Chemical and Petroleum Instrumentation, St. Louis April 6-7

American Institute of Mining & Metallurgical Engineers, 42nd National Open Hearth Steel Conference and Blast Furnace, Coke Ovens and Raw Materials Conference, Jefferson Hotel, St. Louis April 6-8

American Society of Mechanical Engineers, Hydraulic Div. Conference, University of Michigan, Ann Arbor, Mich. April 13-15

Conference on Industrial Instrumentation & Control, sponsored by Armour Research Foundation, Illinois Tech campus April 14-15

American Institute of Electrical Engineers, Recording & Controlling Instrumentation Committee, Third National Conference on Analog & Digital Instrumentation, Philadelphia April 20-21

Instrument Society of America, Oak Ridge Section, Fifth Annual Southeastern Regional ISA Conference & Exhibit, Gatlinburg, Tenn. April 20-22

Institute of Environmental Engineers, Third Annual Technical Meeting, LaSalle Hotel, Chicago April 22-24

Scientific Apparatus Makers Association, 41st Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va. April 25-30

MAY

Instrument Society of America, Fifth National Instrumentation Flight Test Symposium, Seattle May 4-7

Interdisciplinary Conference on Self-Organizing Systems, sponsored by Office of Naval Research (Information Systems Branch) with Armour Research Foundation, Museum of Science & Industry, Chicago May 5-6

1959 Electronics Components Conference, sponsored by AIEE, IRE, EIA, and WCEMA, Benjamin Franklin Hotel, Philadelphia May 6-8

Instrument Society of America, Second National Power Instrumentation Symposium, Kansas City, Kan. May 11-13

American Institute of Electrical Engineers, Joint Conference on Automatic Techniques, Pike Congress Hotel, Chicago May 11-13

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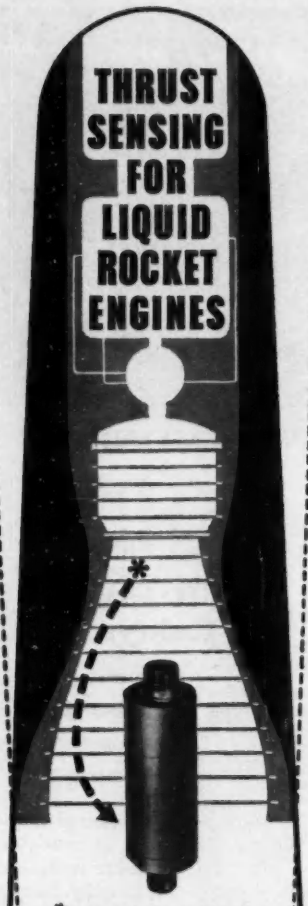
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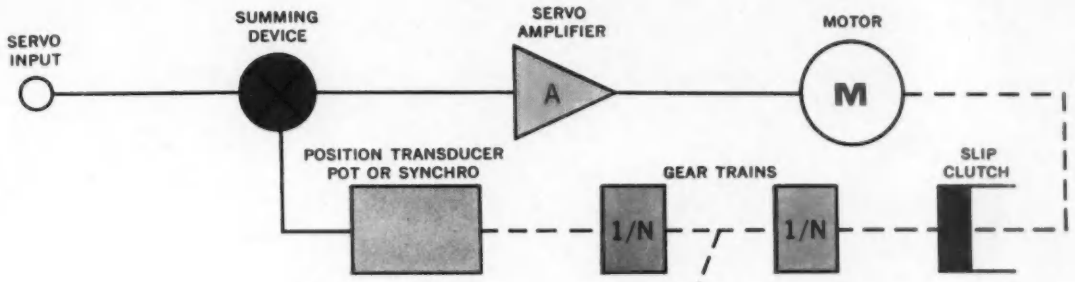
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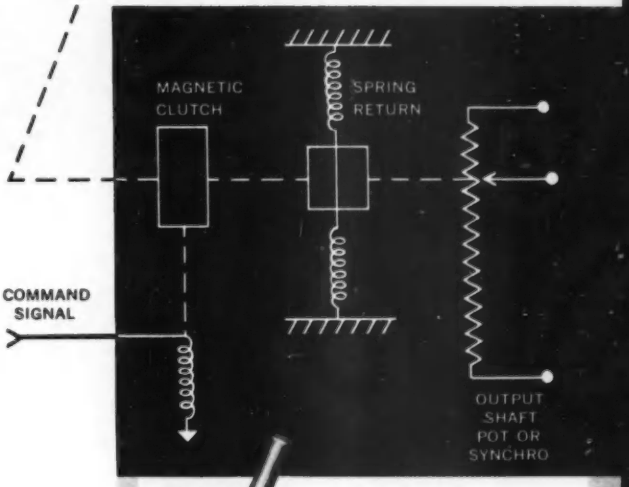
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